A

REFERENCE HANDBOOK

OF THE

MEDICAL SCIENCES

BEING A COMPLETE AND CONVENIENT WORK OF REFERENCE FOR INFORMATION UPON TOPICS BELONGING TO THE ENTIRE RANGE OF SCIENTIFIC AND PRACTICAL MEDICINE, AND CONSISTING OF A SERIES OF CONCISE ESSAYS AND BRIEF PARAGRAPHS, ARRANGED IN THE ALPHABETICAL ORDER OF THE TOPICS OF WHICH THEY TREAT

PREPARED BY

WRITERS WHO ARE EXPERTS IN THEIR RESPECTIVE DEPARTMENTS

ILLUSTRATED BY CHROMOLITHOGRAPHS AND FINE WOOD ENGRAVINGS

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PREFACE.

The character and scope of the Handbook may be judged better from a brief inspection of the present volume than from any detailed description which I might be able to give. It is essentially a collection of articles—some brief, others of considerable length—treating of many of the more important topics in regard to which medical men are likely to desire information. In selecting these topics, and in determining how much space should be allotted to each, I have been guided by the following considerations: In the first place, the size of the entire work—eight volumes of about eight hundred pages each—precluded the possibility of treating exhaustively all the topics for which one might fairly consider it necessary to make provision. In the presence of this difficulty I was obliged to choose between two courses: either to retain a reasonably full list of topics, and give to each its proper share of space; or to curtail the list, and so gain enough space for a fairly satisfactory and thorough treatment of at least the more important subjects. The former plan, which to many would appear to be the more natural one of the two, and which is in fact the one generally pursued in works of a similar character, leads inevitably to the production of a book containing articles so brief and so lacking in fulness of information that the reader cannot fail to experience more or less disappointment in them. The latter plan, on the other hand, is open to the objection that the reader will now and then search in vain for information in regard to some topic in which he is interested. Between these two plans I have not hesitated to choose the latter. The objections which may be brought against it seem to me to be fewer and of less weight than those which are inseparable from the more strictly symmetrical plan of construction. The advantages, on the other hand, appear to me to more than compensate for the defects. Under this plan the editor feels himself at liberty to use his own judgment in regard to the selection of topics and in regard to the degree of importance which shall attach to each. In the next place, it has seemed to me desirable to bear in mind the varied tastes and professional wants of those who are likely to make use of the Handbook. While, therefore, I have given the lion's share of the space to matters of a practical nature—the diagnosis and treatment of disease—I have not forgotten to make ample provision for such departments as medical botany, climatology, embryology, physiological and pathological chemistry, applied anatomy, medical jurisprudence, military and naval surgery.

In harmony with these considerations I have not hesitated to leave out separate articles on some of the topics which appear as independent headings in other works of a similar character; and, on the other hand, I have introduced articles on many topics which are not discussed in any of the treatises which ordinarily find their way into the libraries of medical men.

In working out the problem which was set before me as editor, I have derived not a little assistance from Quain's "Dictionary of Medicine," from Eulenburg's *Real Encyclopädie,* and from Jaccoud's *Nouveau Dictionnaire de Médecine et de Chirurgie Pratiques.* I have also received valuable aid from Drs. Charles Sedgwick Minot, James J. Putnam, and W. P. Bolles, of Boston; Drs. William Osler and Arthur Van Harlingen, of Philadelphia; Dr. John Green, of St. Louis; Surgeons Charles A. Smart, B. A. Clements, and Alfred A. Woodhull, of the United States Army; and Drs. Frank P. Foster,

Huntington Richards, D. Bryson Delavan, Edward Curtis and Mr. Benjamin Vaughan Abbott, of New York, to all of whom I desire to express publicly my thanks. In the difficult task of correcting the proof-sheets, I have been aided by Drs. William H. Flint, Huntington Richards, and Thomas L. Stedman, of this city. I also take pleasure in acknowledging the assistance afforded, in the department of Climatology, by Hon. H. B. Small, of Ottawa, Canada; Professor J. C. Smock, of New Jersey, and many others whom I have not the space here to mention.

It also gives me pleasure to acknowledge the generous manner in which the publishers have acceded to all my requests and suggestions in regard to the construction of the book; some of these requests involving a considerable increase in the expense of publication.

This volume, as will be noticed, is not self-indexing. Without a reasonably exact knowledge of the contents of the remaining seven volumes, it would not be possible to introduce such a running index, or at least one that would be sufficiently complete to be really useful. It seemed to me, therefore, that much valuable space might be saved by omitting altogether the independent cross-references (*i.e.*, those which constitute separate headings), and introducing, instead, at the end of the work, a reasonably full index.

Finally, I desire to call attention to the running titles at the upper corners of the pages. These are intended to aid the reader in searching for a particular topic, and they are therefore placed where they can be most easily seen in turning over the pages rapidly. The upper title always indicates the first topic on the left-hand page, and the lower one the last topic on the right-hand page.

A. H. B.

NEW YORK, August 31, 1885.

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Aachen.

AACHEN (Fr. Aix-la-Chapelle), renowned for the number, variety, and singular efficacy of its springs since the days of Charlemagne, has maintained its ancient repute, and in our own times ranks as one of the most valuable of health resorts. It is a city of Rhenish Prussia, near the western border of the empire (Lat. 50° 47′ N., Long. 6° 12′ E.). Its elevation above the level of the sea is about 565 feet. Its name is derived from the Teutonic Aa, Aach = water (Latin, Aqua). The great quantities of thermal waters which well up from numberless springs in its immediate vicinity justify the appellation. The most noteworthy of the springs are the Kaiserquelle, having a temperature of 55° C. (131° F.), Quirinusquelle, 50° C. (122° F.), Rosenquelle, 47.5° C. (117.5° F.), and the Corneliusquelle, 45.5° C. (114° F.). Their waters supply, in addition to the Elisenbrunnen, which has a temperature of 53° C. (127.5° F.), eight sumptuously arranged bathing establishments, of which those known as the "Kaiserbad" (rebuilt in 1864), the "Königin von Ungarn," the "Neubad," and the "Quirinusbad" are the most prominent. The waters are all of them but slightly impregnated with carbonic acid gas; their chief saline constituent is sodium chloride. They contain, besides, a small proportion of bromine and iodine. Sulphur is an important component part. The Kaiserquelle contains it in greatest abundance; but in all of the springs the amount and chemical condition of the sulphur present are subject to great and frequently varying change. The presence of sodium carbonate in the water points to the proximity of extinct Eifel volcanoes. The chemical composition of all the waters varies only within very narrow limits. According to the analysis of J. von Liebig, the Kaiserquelle, which may serve, for all practical purposes, as a standard for the others also, contains in 10,000 parts of water:

Sodium chloride	26 161
Sodium bromide	0.036
Sodium iodide	0.005
Sodium sulphide	0.095
Sodium sulphate	2.836
Potassium sulphate	1.527
Sodium carbonate	6.449
Lithium carbonate	0.029
Magnesium carbonate	0.506
Calcium carbonate	1.579
Strontium carbonate	0.002
Ferrous carbonate	0.095
Silica hydrate	0.661
Organic matter	0.769
Total	40.791
Carbonic oxide (free and partially free)	5.000

Traces of fluorine, boron, and arsenic. There is probably an organic sulphide (allyl) present in minute quantity.

The action of the Aachen thermal water on the economy is analogous to that of any chloride water of the same temperature. By reason of its alkalinity it does not generally disturb the stomach. The sulphates frequently produce a slight aperient effect; but where baths are taken simultaneously with the habitual drinking of the waters, this laxative action is annulled, and a slight constipation not infrequently ensues. The sodium sulphate is probably the great factor in producing therapeutic effects in torpid conditions of the abdominal viscera, particularly on the mucous membranes of the intestinal tract. Its presence, although in minute quantity, is easily appreciated by the senses. The sulphate is either absorbed unchanged, or is decomposed into hydrogen sulphide, and taken into the blood-current as such: in either case it promotes metamorphosis of the blood-disks and albumen, and has a distinct solvent action on metallic deposits in the tissues. The researches of Güntz have shown that the internal use of Aachen waters promotes the secretion of urea, and it follows that protein decomposition is accelerated in proportionate ratio. This is further proven by the appearance or increase of xanthin in the urine of Aachen patients. In hydrargyrosis, the drinking of the water of the Kaiserquelle produces elimination of mercury by the kidneys.

For purposes of local treatment the waters are used as baths, which are taken in stone basins. There are no integumentary irritants in the waters; hence there are no immediate local effects. Neither is the temperature at which the bath is taken high enough to act by its caloric property; but the sulphur, which in the bath water is suspended in the most minute particles, adheres to the skin, and finds lodgment in the pores, but it is still an open question whether it is possible for the sulphur to find its way into the absorbents in this way. The alkaline reaction of the bath imparts emollient properties to it; it exerts also a solvent action on the sebum and other fatty skin elements, and promotes absorption in this way; and this may explain why inunctions immediately following the bath, are so remarkably prompt in their action. The temperature of the bath usually varies from 33° to 36° C. (91.4° to 96.8° F.); it rarely fails to act as a sedative. A method of bathing peculiar to Aachen consists in the application of a douche in a manner differing from that pursued in any other place. A stream of warm water is poured from a hose upon the bather for ten or fifteen minutes, from a height varying from five to ten metres (16 to 32 ft.). The streams used vary in diameter from three to nine millimetres, and the temperature of the water ranges from 35° to 37° C. (95° to 98° F.). For a period of from five to twenty minutes the douche is kept playing upon the back and limbs, and especially over the affected regions. At the same time, massage and shampooing are carried out by a skilled attendant. The mechanical and thermic effects of these procedures are made manifest by reddening of the skin and profuse diaphoresis. They are very agreeable to the patient, and do certainly act as a lymphatic stimulant. They promote absorption of chronic inflammatory products, and of syphilitic, rheumatic, and gouty new-formations; and it is this tissue metamorphosis which is the object of an Aachen cure and which is hardly attainable, in the same degree, at any other bath on the Continent.

Syphilis is not treated exclusively by the water cure: inunctions with mercurials and the internal administration of mercury and potassium iodide are resorted to simultaneously; and although such a complex treatment would seem to prove nothing as to the waters themselves, experience has shown that the specific treatment alone is not as efficacious as the combined specific and thermal treatment. The same statement will hold

good with regard to gout, rheumatism, acne, eczema, furunculosis, metallic deposits and their systemic effects; and, lastly, with regard to all diseases of the abdominal viscera characterized by engorgement, hypertrophy, and new growth. The singular effectiveness of the Aachen baths has led to the artificial preparation of the same, but neither the prepared Aachen bath water nor the Aachen soap produces the least effect, excepting in the imagination of the patient. The water of the "Elisenbrunnen" is bottled for export. Aachen enjoys another advantage which is of some moment: it is situated in a mild latitude, where no great variation of temperature is ever experienced; it is rarely visited by epidemics; in the main there is plenty of space around the houses; in a word, it is admirably adapted for a place of sojourn in the winter months, and the number of guests who frequent it during this season of the year is gradually becoming greater, so that it can hardly be said that there is a limited season. (The preceding account is derived from Eulenberg's "Real Encyclopädie.")

Henry Fleischner.

ABDOMEN.—MEDICAL AND SURGICAL APPLIED ANATOMY.—The term abdomen is applied to the cavity bounded above by the diaphragm, below by the iliac fossæ and brim of the true pelvis, behind by the lumbar vertebræ, and at the sides and front by the abdominal muscles. The space thus included extends upward far under the chest-walls. Its summit is formed by the convexity of the diaphragm, which reaches upward to the level of the fifth right chondro-sternal articulation. A horizontal section of the body at this level will shave off just a thin slice of liver covered by the diaphragm. On the left side the arch of the diaphragm reaches but as high as the level of the junction of the sixth rib with the sternum. Posteriorly the vertebral column, covered by the crura of the diaphragm, projects into the abdominal cavity. The distance from the umbilicus to the lumbar vertebræ is scarcely more than two inches. The lateral portions of the posterior wall are formed by the psoas, which rests closely against the sides of the bodies of the lumbar vertebræ, as well as the quadratus lumborum, a thin plane of muscle lying between the posterior portion of the crest of the hip-bone below and the last rib above, and the apices of the transverse processes of the lumbar vertebræ toward the middle line. The sides and front of the abdomen are formed by the three flat muscles, the obliquus externus, obliquus internus, and the transversalis, united at the linea semilunaris to enclose the fourth abdominal muscle, the rectus, which is the anterior boundary of the belly-wall. The space thus enclosed contains the stomach, the intestines, the liver, the spleen, the pancreas, the kidneys and their ducts, the vessels of the trunk, nerves and lymphatics.

SUPERFICIAL ANATOMY OF THE ABDOMEN.—The belly is convex on its anterior surface, more especially so in the corpulent. Unusual prominence of the lower part of the belly is often seen in those whose chests are shallow. Infants are normally pot-bellied, owing to the relatively large size of the solid viscera, as well as to the narrowness of the pelvis. In rickets, as in other conditions of malnutrition in children, the belly becomes very prominent, partly from a depression of the liver and spleen, partly by reason of the anterior curvature of the spine and the fact that the intestines in this disease are commonly distended with gas. In cretins the belly is pendulous from laxity of the skin, and after pregnancy, ascites, and ovarian dropsy the abdominal wall tends to remain permanently flaccid. Retraction of the anterior abdominal wall is seen in diseases accompanied by much emaciation. In tubercular meningitis it is a very marked symptom, helping to distinguish it from enteric fever, in which there is usually tympanitis. In peritonitis gas distends the cavity, and abdominal respiratory movement ceases. Various kinds of skin eruption appear upon the surface of the abdomen. Herpes zoster is seen upon one or other side of the trunk, following the course of the intercostal nerves. The rash of typhoid fever is dotted over the front of the abdomen. Often, when absent in front, it is to be found over the lumbar region, and the same may be said of the syphilitic secondary rash. Tinea versicolor sometimes descends from its favorite position on the front of the chest, and spreads out upon the abdomen. In the vicinity of the navel, scabies is often met with, while eczema prefers the scrotal integument.

The pit of the stomach is that depression in the middle line just below the ensiform appendix. Here the skin is tender and sensitive. A blow upon the scrobiculus cordis, as the older writers called it, is dangerous. The solar plexus lies underneath the pit of the stomach. In a few cases fatal results have immediately followed an injury of this nature. The epigastrium is the seat of pain in stomach affections generally, and to it is referred the feeling we call hunger, and that condition impossible to define, nausea. The ingestion of irritant poisons is followed by burning pain at the pit of the stomach. Conversely, counter-irritation in this region will relieve gastric pain and nausea. There are few remedial agents so efficacious as a mustard poultice to the pit of the stomach in severe gastralgia, whether of organic origin or not. What, then, is the connection between the stomach and the skin of the epigastric region? The sympathetic nerves which supply the stomach are the branches of the cœliac plexus, which is derived from the fore part of the great solar or epigastric plexus. The semilunar ganglion is part of the solar plexus; it receives the great splanchnic nerve, the origin of which is from the lower thoracic ganglia. Each of these thoracic ganglia is connected to the nearest anterior root of the spinal nerves. Now it happens that the skin of the epigastrium is supplied by these very same nerves, viz., from the fourth to the seventh intercostal nerve. There is therefore a complete nervous circuit from the mucous membrane of the stomach to the skin of the epigastrium.

In the mid-line in front is the depression of the linea alba, the abdominal furrow. At about its centre is the umbilicus, the remains of that opening in the abdominal wall through which there passed the structures connecting the embryo with the internal surface of the ovum. The linea terminates below in the symphysis pubis, and above in the tip of the sternum. In this median depression, the linea alba, the incision is made in all cases where the surgeon has to open the abdominal wall, as in ovariotomy, Cæsarean section, and other operations. The prominence formed by the rectus muscle lies on each side of the furrow. In thin, muscular subjects the transverse marks on the rectus are plainly perceptible. There are usually three of these cross-marks—one at the level of the navel, one just below the ensiform appendix, and a third between these two points. In the living body not more than two are commonly perceptible.

The abdominal aorta lies a little to the left of the middle line, with the inferior vena cava on its right side. The bifurcation takes place opposite the middle of the body of the fourth lumbar vertebra, three-quarters of an inch below and to the left of the umbilicus. This point is nearly on a level with a line drawn from the highest point of the iliac crest to the other. A line drawn from it to the midpoint between the iliac spine and the symphysis pubis indicates the direction of the common and external arteries. The upper third of this line represents the common, and the lower two-thirds the external iliac.

The cœliac axis arises from the aorta at a point four inches above the umbilicus. Posteriorly it corresponds to the lower part of the body of the last dorsal vertebra, opposite the first lumbar spine. Immediately below the cœliac axis is the pancreas, which crosses the arch of the aorta and the vertebral column at a point between three and four inches above the umbilicus. Below the pancreas is the superior mesenteric artery, two or three inches above the navel. One inch above the umbilicus the duodenum crosses the aorta. Immediately beneath the duodenum, about one inch above the navel, the inferior mesenteric artery is given off. At the outer border of the prominence formed by the rectus muscle is a shallow depression on each side, the upper ends of which are bent in toward the middle line. This is the

linea semilunaris, the point where the aponeuroses of the abdominal fasciæ unite just before they diverge to form the sheath of the rectus. Its direction corresponds with that of a slightly curved line drawn from the tip of the ninth costal cartilage to the spine of the pubes. In former days incisions for paracentesis were made in the linea semilunaris. In one reported case at least, the trocar struck the epigastric artery, just as it crossed the line. The operator was the illustrious Cline.[1] The preparation is to-day in the Museum of St. Thomas' Hospital.

The spine of the pubes is an important landmark. In the male subject it is to be felt from below by tucking up the scrotal tissues with the forefinger. The line of the adductor longus, which is made manifest by abduction of the thigh, leads up to it. The spine having been

FIG. 1.—Superficial Abdominal Veins distended from Intra-thoracic Pressure. The superficial thoracic veins are also enlarged, though not represented by the engraver.

found, the external ring may be felt immediately to its outer side. In the normal condition of parts the tip of the finger should feel a slight depression over the ring, and when the patient coughs anything like a distinct impulse should not be felt. When a patient has had a rupture for some time, the sharp edges of the ring disappear, and the finger slips easily through the opening into the abdominal cavity. The spine of the pubes is on a horizontal line with the upper edge of the great trochanter. The internal ring corresponds to a point upon the surface midway between the anterior superior spinous process of the ileum and the symphysis pubis and half an inch above Poupart's ligament. Between the two rings the epigastric artery takes its course from its origin from the external iliac artery upward and inward toward the umbilicus. Passing over Poupart's ligament, and superficial to the deep abdominal (Scarpa's) fascia are the branches of the femoral artery and vein which ascend up the abdominal surface, the superficial epigastric and superficial circumflex iliac. These veins become enlarged when there is obstruction to the circulation in the abdomen. Figure 1 is a portrait of my patient, Jean Larance, aged fifty-nine, in whose case thoracic aneurism was diagnosed. The superficial abdominal veins are as thick as one's little finger, and are very tortuous. The superficial epigastric vein becomes lost in the enlarged venous plexus on the surface of the thorax; the superficial circumflex iliac vein is directly continuous with the axillary veins. Billroth records a similar case of enormous enlargement of superficial abdominal veins. The autopsy showed the presence of a malignant bronchocele in the upper part of the chest, causing pressure upon the innominate vein on the left side.

REGIONS OF THE ABDOMEN AND THEIR CONTENTS.

For purposes of description the abdomen has been divided into nine regions. The landmarks from which the boundary lines of these are to be drawn vary according to different authors. The most satisfactory directions are as follows: Draw a horizontal line on a level with the lowest part of the thoracic wall on each side, another horizontal line on a level with the highest part of the iliac crests. Bisect Poupart's ligament, and through each point of bisection draw a vertical line upward. The abdominal surface is thus divided into nine regions, named as in the diagram.

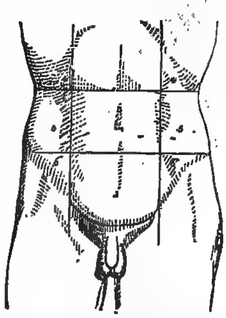

FIG. 2.—Outline of the Front of the Abdomen, showing the Division into Regions. 1, Epigastric region; 2, umbilical; 3, hypogastric; 4, 4, right and left hypochondriac; 5, 5, right and left lumbar; 6, 6, right and left iliac. (From Quain.)

THE RIGHT HYPOCHONDRIAC REGION.—This region contains the greater part of the right lobe of the liver, whose convexity is in relation with the concavity of the diaphragm, the hepatic flexure of the colon, and part of the right kidney. That surface of the liver which is now called upper, corresponds with the surface in contact above with the diaphragm, and in front with a portion of the anterior chest-wall. Morbid adhesions between the liver and diaphragm are of not uncommon occurrence, notably in cirrhosis, where the junction of the two surfaces enables the branches of the portal vein to communicate with the veins of the diaphragm. These veins take the course of the phrenic arteries, on the left side often joining the left renal vein. Portal engorgement is in this way partly relieved. Frerichs has been able to make out this communication in every case in which he has injected the portal vein.

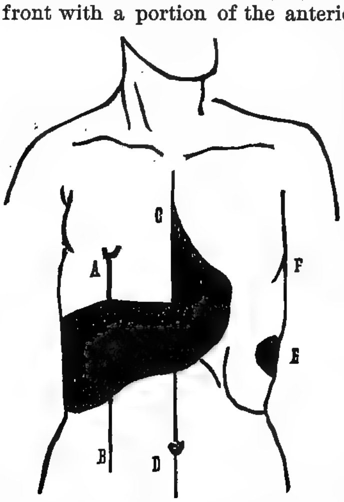

FIG. 3.—Area of Hepatic Dulness Viewed Anteriorly. A, B, right mammary line; C, D, median line; E, splenic dulness; F, cardiac dulness. (After Murchison.)

Hepatic Dulness.—The upper margin of hepatic dulness on percussion is not exactly defined. The flat note elicited on percussion over the liver becomes gradually clear as we percuss upward, the reason being the fact that a margin of clear lung overlaps the convex upper surface of liver. The line at which abso-

lute dulness ceases is spoken of as the upper margin of hepatic dulness. This line is not quite horizontal, but is somewhat arched. "Commencing posteriorly at about the tenth or eleventh dorsal vertebra, it ascends gradually

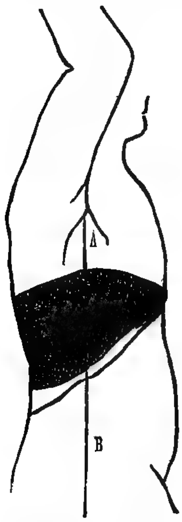

FIG. 4.—Area of Hepatic Dulness viewed from the Right Side. A, B, right axillary line.

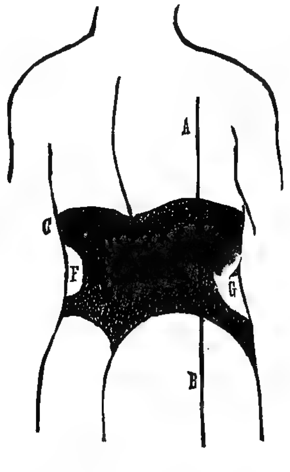

FIG. 5.—Area of Hepatic Dulness viewed Posteriorly. A, B, right dorsal line; C, splenic dulness; D, left kidney; E, right kidney; F, descending colon; G, ascending colon.

toward the axilla and nipple, and then again descends slightly toward the middle line in front" (Murchison). In the right mammary line, which is an imaginary straight line let fall vertically from the right nipple, the upper margin of hepatic dulness is situated in the fifth intercostal space. In the median line in front, it usually corresponds to the base of the ensiform cartilage, or rises slightly above it. To the left of the sternum, the upper margin of liver dulness is lost in that of the heart (see Epigastric Region); "but a line drawn from the upper margin of hepatic dulness in the middle line to the apex of the heart, will usually correspond to the line of separation. In the right axillary line, a line falling perpendicularly from the centre of the axilla, the upper margin of hepatic dulness corresponds to the seventh intercostal space, or more rarely to the seventh rib. In the right dorsal line, or a line falling perpendicularly from the angle of the scapula, when the arm is dependent, it corresponds to the ninth intercostal space or the ninth rib" (Murchison). Percussion and palpation determine the lower margin of hepatic dulness. In the right mammary line it corresponds roughly to the lower margin of the thoracic wall. In the right axillary line it is opposite the tenth interspace, and in the right dorsal line, the twelfth rib. The gall-bladder projects opposite the ninth right costal cartilage, close to the outer edge of the rectus abdominis.

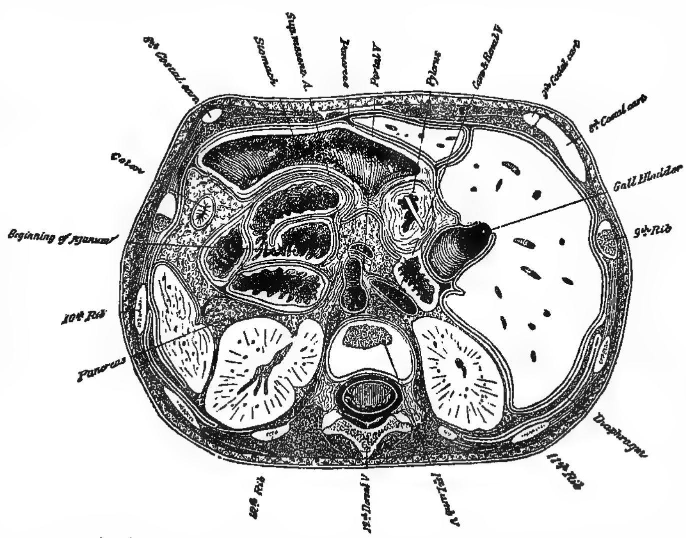

FIG. 6.—Horizontal Section just above the Body of the First Lumbar Vertebra. (From Dwight.)

The size of a liver is usually measured by the extent of dulness in the right mammary line, which in an ordinary adult is about 4 inches, and by that in the axillary and dorsal lines, which measure respectively 4½ and 4 inches.

Parts in the Transverse Fissure of the Liver.—From before backward there are found in the transverse fissure of the liver the bile-duct, the hepatic artery, and the portal vein. These structures lie between the layers of the gastro-hepatic omentum at its right border, in front of the foramen of Winslow. The duct lies most to the right side, the artery toward the left. There are many lymphatics and nerves in the transverse fissure. These important structures are so closely related that alterations in size or shape of one affect the function of the others. The hepatic artery may be the seat of an aneurism, which may press upon the vein and cause portal obstruction and its attendant symptoms, or upon the bile-duct and cause obstructive jaundice. An hepatic aneurism has been known to burst into the gall-bladder (Frerichs). The lymphatic glands in the transverse fissure may enlarge and obstruct either duct or portal vein. Neighboring tumors of all sorts act in the same way. Concretions in the bile-ducts may obstruct the portal vein, or even ulcerate their way into it, an occurrence which is said to have caused the death of Ignatius Loyola. The close relation of the hepatic flexure of the colon to the duct explains the fact that an overloaded bowel may cause jaundice. The nerves of the liver are derived from the cœliac plexus of the sympathetic and the vagus, more especially the left, which sends some filaments between the layers of the gastro-hepatic omentum to join the hepatic plexus. The connection of the nerves of the liver with the solar plexus, and indirectly

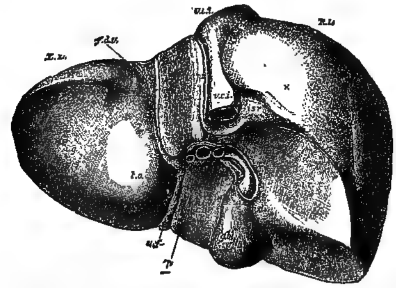

FIG. 7.—The Liver of a Young Subject, sketched from below and behind. (From "Quain's Anatomy.") *R. L.*, right lobe; *L. L.*, left lobe; *L. S.*, lobe of Spigelius; *L. C.*, caudate lobe; *L. Q.*, quadrate lobe; *p*, portal fissure; *u. f.*, umbilical fissure; *f. d. v.*, fissure of the ductus venosus; *g. bl.*, gall-bladder; *v. c. i.*, vena cava inferior; *i, g*, impression on the under surface of the left lobe corresponding to the stomach; *c.*, position of the cardia; *t. o.*, projection of the posterior surface of the left lobe against the lesser omentum (tuber omentale, His); *i. c.*, impressio colica; *i. r.*, impressio renalis; *i. s. r.*, impressio supra-renalis; p^1, p^2, p^3, p^4, lines of reflection of the peritoneum; +, surface of the liver uncovered by peritoneum.

with the splanchnic nerves, serves to explain the pain in and about the right shoulder which is felt in some disorders of the liver, the skin of the parts about the scapula being supplied by the upper dorsal spinal nerves, which are in direct communication with the origin of the splanchnics.

The hepatic artery conveys the main supply of blood for the nourishment of the organ. It may, however, be occluded without causing serious interference with the functional activity of the liver. The collateral circulation, when there is complete or nearly complete obstruction, may be kept up by (1) accessory hepatic arteries, which are sometimes met with coming from the gastric arteries, less frequently from neighboring arteries; (2) the anastomoses of the pyloric artery, provided the obstruction be beyond the giving off of that branch; (3) possibly the portal vein may in such a case nourish and keep up the secreting functions of the liver. The reverse is positively true. The hepatic artery can supply the liver with sufficient blood to carry on its functions when the obstruction of the portal vein occurs.

The hepatic veins which collect the blood from the lobules of the liver open into the inferior vena cava by an oblique entrance, which serves as a valve. In cases of abdominal tumor the effects vary as to the relation of the pressure to this junction of the hepatic vein. If the tumor compresses the inferior vena cava above the

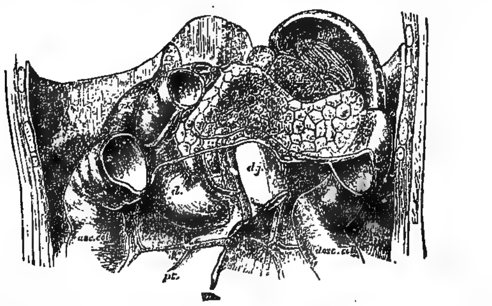

FIG. 8.—The Pancreas and Adjoining Viscera, seen from before. (From Quain.) The stomach, the greater part of the small intestines, and the transverse colon have been removed. *P.*, pancreas; *d.*, duodenum; *d. j.*, its junction with the jejunum; above the duodenum and between it and the head of the pancreas are seen the bile-duct, portal vein, and hepatic artery; *asc. col.*, *desc. col.*, ascending and descending colon; *spl.*, spleen; *r. k.*, *l. k.*, right and left kidney; *s. r.*, *s. r′*, right and left suprarenal capsules; *pt.*, peritoneum, at the back of the abdominal cavity; *m.*, line of reflection of the mesentery; the line of reflection of the transverse mesocolon is seen along the lower edge of the pancreas and crossing the duodenum.

hepatic vein the result will be a damming up of the blood-current in the liver as well as in the general circulation. Œdema of the lower extremities and portal obstruction will both occur. If, on the other hand, the pressure be below the hepatic vein, then œdema of the feet will be the most prominent symptom.

The Portal Vein.—There are no valves in the portal vein. Its left branch is joined in the longitudinal fissure of the liver by the so-called round ligament, which is really the obliterated umbilical vein. This latter is sometimes open during adult life. Osler ("Montreal General Hospital Reports," vol. i.) reports a case of cirrhosis of the liver where the collateral circulation was carried on by means of an enlarged umbilical vein. At the navel this enlarged vessel became continuous with the deep epigastric vessels of the left side. The tributaries of the portal vein originate in the stomach, intestines, pancreas, and spleen. It is made up of the superior and inferior mesenteric and splenic veins, joined by the pyloric and gastric veins, and sometimes by the cystic vein from the gall-bladder. All these viscera, then, would suffer interference of function were there to be impeded circulation in the portal vein. This condition is commonly met with. Its causes, from its anatomical relations, are easily understood, and the symptoms produced thereby are such as might be expected to be met with after consideration of the sources of its tributaries.

1. Engorgement of the gastric and mesenteric veins gives rise to catarrh and hemorrhages from the mucous membrane of the stomach and bowels. 2. Ascites from the over-distention of the veins that return the blood from the peritoneum. 3. The spleen is enlarged from obstruction of the current in the splenic vein. 4. An attempt is made to carry on the current by enlargement of the abdominal veins. 5. Hemorrhoids from stagnation in the hemorrhoidal plexus, the superior hemorrhoidal vein being a tributary of the portal vein.

The hepatic duct leaves the liver and passes down in front of the portal vein, between the two layers of the gastro-hepatic omentum, behind the first part of the duodenum. A stone in the duct may work its way into the stomach and be expelled by vomiting. Fistulæ into the duodenum are not uncommon, indeed a calculus may ulcerate into the duodenum and cause death by obstruction of the small intestine.

THE EPIGASTRIC REGION.—In this region the remainder of the right and nearly all the left lobe of the liver are found. In the middle line of the trunk the heart rests upon the upper surface of the liver, separated

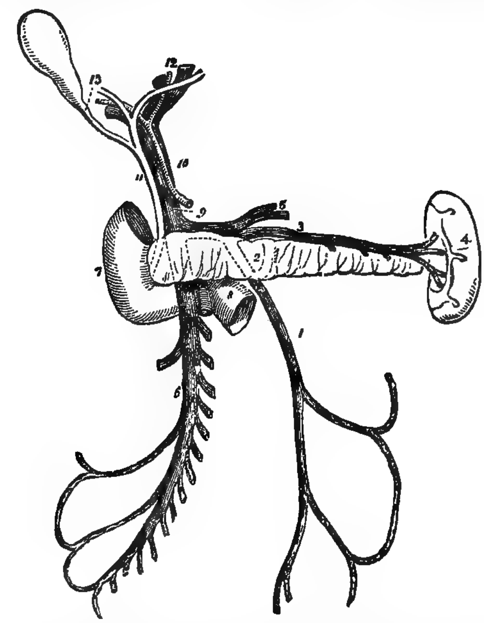

FIG. 9.—The Portal Vein. (From Wilson.) The pancreas drawn down to show the splenic vein behind it. 1, Inferior mesenteric vein, passing behind 2, the pancreas, to terminate in 3, the splenic vein; 4, the spleen; 5, gastric veins opening into the splenic vein; 6, superior mesenteric vein; 7, descending portion of the duodenum; 8, its transverse portion crossed by the superior mesenteric vein and part of the trunk of the superior mesenteric artery; 9, portal vein; 10, hepatic artery; 11, ductus communis choledochus; 12, division of the duct and vessels at the transverse fissure of the liver; 13, cystic duct leading to the gall-bladder.

from it by the pericardium, the diaphragm, and the peritoneum, this last extending three-quarters of its way back between liver and diaphragm before its reflection The left ventricle and right auricle of the heart are in close relationship with the liver, and there passes through it the inferior vena cava. This relation is illustrated by a remarkable case quoted by Treves. "A loose piece of liver, weighing one drachm, was found in the pulmonary artery. The patient had been crushed between two wagons; the liver was ruptured and the diaphragm torn. A piece of the liver had been squeezed along the vena cava into the right auricle, whence it had passed into the right ventricle, and so into the pulmonary artery. The heart was quite uninjured." A needle thrust through the abdominal wall at the tip of the xiphoid appendix, from before backward, would most probably pass through the diaphragm, the left lobe of the liver, the lobus Spigelii, the diaphragm again, the vena azygos

major, and strike the lower edge of the tenth dorsal vertebra. The lower margin of the liver in the epigastric region extends in contact with the abdomen in a line from the ninth right to the eighth left costal cartilage, and in the middle line its depth below the subcostal angle may be roughly estimated at 3½ or 4 inches, about a hand's breadth. On the right of the epigastric region

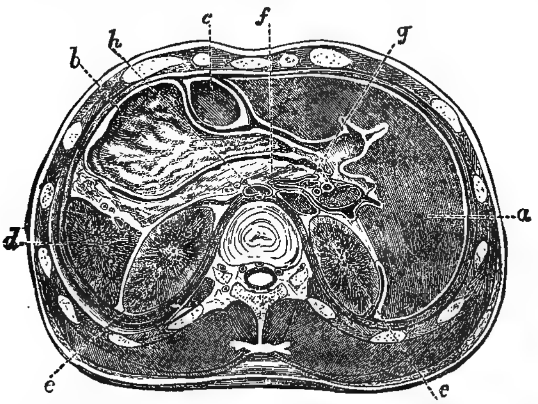

FIG. 10.—Horizontal Section through the Upper Part of Abdomen. (From Treves, after Rüdinger.) *a*, Liver; *b*, stomach; *c*, transverse colon; *d*, spleen; *e*, kidneys; *f*, pancreas; *g*, inferior vena cava; *h*, aorta, with thoracic duct behind it.

is found the gall-bladder, opposite the ninth cartilage, close to the margin of the rectus muscle. Underneath the liver on the right, and under the diaphragm on the left of the space, the stomach is situated, occupying from time to time a varying position. Its two orifices are found in the epigastric region; the cardiac, usually a fairly fixed point, is behind the seventh left costal cartilage, one inch from the sternum; while the pyloric end is continually shifting its position, being found two or three inches below the ensiform appendix, and moving toward the right as it becomes distended. The first and second parts of the duodenum are deeply placed. A horizontal cut through the abdomen, one inch below the ensiform cartilage, shows the transverse portion of the duodenum, situated in a square, of which the four sides are formed, in front by the hepatic flexure of the colon; to the right by the liver, behind by the kidney,

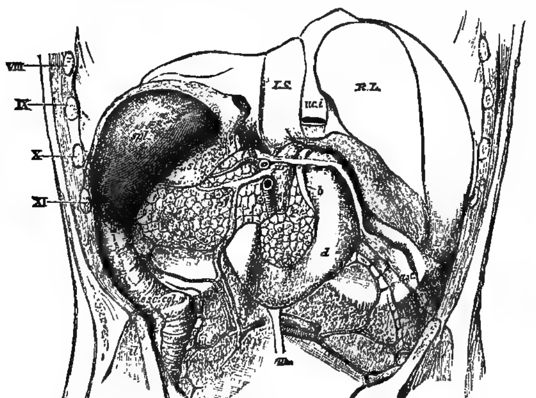

FIG. 11.—View of the Abdominal Viscera from Behind, after removal of the Spinal Column and the whole of the Posterior Wall of the Abdomen, the Peritoneum being left. (From Quain, after His.) *P.*, pancreas; *P'*, its head; *d.*, duodenum; *st.*, stomach; *spl.*, spleen; *R. L.*, right lobe of the liver; *L. S.*, Spigelian lobe; *v. c. i.*, vena cava inferior; *p. r.*, portal vein; *b.*, common bile-duct; *i. r.*, impression for the right kidney on the posterior surface of the liver (the situation of the two kidneys is well shown by the corresponding impressions in the cut); *asc. col.*, *desc. col.*, ascending and descending colon; *pt.*, back of the peritoneum; *m.*, line of reflection of the mesentery seen through; *VIII*, *IX*, *X*, *XI*, the corresponding ribs; *il.*, ilium.

and toward the middle line by the pancreas. (See Fig. 11.) At the back of the epigastric region the abdominal aorta and vena cava inferior lie against the bodies of the twelfth dorsal and first, second, and third lumbar vertebræ. A needle passed in one inch below the ensiform appendix and pushed horizontally backward to the spine would, after passing through the integuments, wound (1) linea semilunaris, (2) the left lobe of the liver, (3) the stomach, (4) the anterior and posterior layers of the lesser bag of the peritoneum, (5) the cœliac axis, (6) the aorta, (7) the junction of the twelfth dorsal and first lumbar vertebræ.

The pancreas extends horizontally across the epigastric region, being curved forward from side to side, over the arch of the vertebral column, like a towel thrown across one's arm. Its horizontal level is about three or four inches above the umbilicus. In a horizontal section of the frozen body, through the first lumbar vertebra, the saw splits the pancreas from end to end.

The spleen, in its upper and inner part, and a small portion of the kidneys, are also included in the epigastric region.

THE LEFT HYPOCHONDRIAC REGION.—The upper and anterior portion of this region is occupied by the stomach, which is covered toward the right side by a small part of the left lobe of the liver. The spleen is packed away in the outer and back part of the region. To the front of the spleen lies the stomach; to its left side the tail of the pancreas and the left kidney. The cardiac end of the stomach is situated opposite the seventh costal cartilage of the left side, one inch from the sternum. When full, the stomach occupies the left hypochondriac and epigastric regions, a small portion projecting into the right hypochondriac region. It lies partly in apposition with the anterior wall of the abdomen, and partly underneath the liver and diaphragm, and above the transverse colon. The relations of the stomach vary with its distention. As it fills, the surface which was formerly anterior becomes superior, and the great curve comes to the front. The pyloric end is pushed over nearly three inches to the right of the median line when the stomach is distended, but when it is quite empty the pylorus remains on the left of the linea alba. When a gastric ulcer is present, and threatening to perforate, Nature often attempts to stop the leak by attaching the stomach to neighboring organs. Thus adhesions to the diaphragm, to the pericardium, the liver, the colon, are not uncommon. Sometimes the process goes too far, and fistulous communication between the stomach and these other cavities is the result. The close relation of the stomach with the viscera immediately behind it, the pancreas, the left kidney, and the spleen, renders difficult the accurate diagnosis of the diseases to which these parts are subject. It is not uncommon to find malignant disease of the pylorus attacking, at the same time, the spleen, liver, and kidneys. In connection with gastrotomy and gastrostomy, the relation of the stomach to the abdominal wall is of importance. That part of the abdominal wall with which the stomach is in apposition

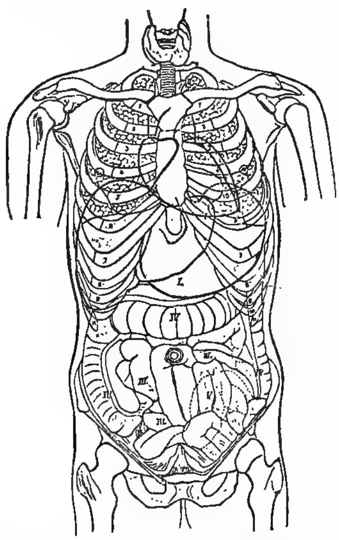

FIG. 12.—View of the Abdominal Organs from in Front. (From Ranney, after Luschka.) The numerals are placed upon the respective ribs, I., the stomach; II., duodenum; III., ileum; IV., colon; V., sigmoid flexure.

corresponds to a triangle upon the surface of the body, of which the sides are formed on the right by the edge of the liver, on the left by the cartilage of the eighth and ninth ribs, and below by a horizontal line passing between the tips of the tenth costal cartilages. Gastric fistulæ usually occur in this space. The operation is generally performed by an incision in the triangle abovementioned, along the course of the left linea semilunaris, from the sternal end of the intercostal space, between the eighth and ninth ribs, vertically downward, along the border of the rectus. The stomach, being reached in this way, is withdrawn far enough to prevent the escape of its contents into the abdominal cavity. In gastrostomy the stomach-wall is stitched to the margin of the incision, and subsequently an opening is made into it.

The spleen lies between the stomach and the ribs, beneath the diaphragm, and above the kidney and the colon, in contact with the diaphragm, from which it is separated by peritoneum, and connected with the pancreas by its vessels. The peritoneum encloses the spleen in, as it were, a bag, of which the front portion is derived from the anterior layer of the gastro-hepatic omentum, and the back portion is continuous with that part passing over the back of the kidney. On the surface the spleen is situated opposite the ninth, tenth, and eleventh ribs of the left side, and at its upper edge is separated from them by the diaphragm, and also by the margin of the lung. The highest and lowest points correspond to

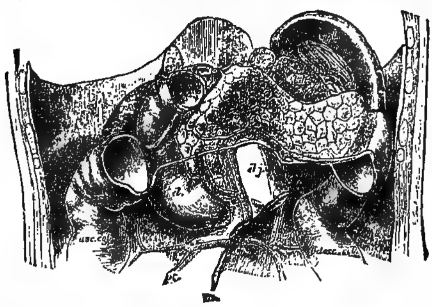

FIG. 13.—The Pancreas and Adjoining Viscera from Before. (From Quain.) The stomach, the greater part of the small intestines, and the transverse colon have been removed. *P.*, pancreas; *d.*, duodenum; *d. j.*, its junction with the jejunum; above the duodenum, and between it and the head of the pancreas are seen the bile-duct, portal vein, and hepatic artery; *asc. col.*, *desc. col.*, ascending and descending colon; *spl.*, spleen; *r. k.*, *l. k.*, right and left kidneys; *s. r.*, *s. r.*, right and left suprarenal capsules; *pt.*, peritoneum at the back of the abdominal cavity; *m.*, line of reflection of the mesentery; the line of reflection of the transverse mesocolon, as seen along the lower edge of the pancreas, and crossing the duodenum.

the level of the ninth dorsal and first lumbar spines. The longest diameter is directed forward and downward, following the direction of the tenth rib. The spleen rarely if ever can be depressed below the free border of the costal cartilages; hence, unless enlarged, it cannot be felt by the hand. The percussion note of the spleen is by no means as flat as that obtained from the liver, especially in the case of children; in fact the upper third of the organ, covered by lung, even in expiration, is not to be defined by percussion. The notches or depressions on the surface of an enlarged spleen serve to distinguish it from any other tumor in the left hypochondriac region. As a rule, there is one large fissure to be made out by palpation, as well as one, sometimes two, smaller ones.

THE RIGHT LUMBAR REGION.—The ascending colon is situated far back up against the posterior abdominal wall, in relation with the right kidney and the quadratus lumborum; the front of the region is occupied by the ileum. The ascending colon is deeply placed, being external to the peritoneum, and bound down by it to the quadratus lumborum, but in some instances the intestine is more free, there being a mesocolon, which is sometimes several inches long. The right kidney is also extra-peritoneal; it rests upon the eleventh and twelfth ribs, the crura of the diaphragm, psoas, and quadratus lumborum, and is covered in front by a thick investment of adipose tissue and the peritoneum. The upper end of the kidney makes its *impressio renalis* upon the under surface of the right lobe of the liver; the anterior surface is in relation with the ascending duodenum and the hepatic flexure of the colon. A study of the relations of the kidney (see Fig. 14) will show that the organ could be operated upon from behind, or even removed, without necessarily wounding the peritoneum or injuring an organ. In hydronephrosis, and in cases where any large cyst exists in the substance of the kidney, puncture should be practised. The trocar should be inserted into any spot where the skin looks thin and soft, but in the absence of any such indication, no better place can be selected on the left side than an inch in front of the last intercostal space; but if the tumor be of the right side, this is too high, as the liver would probably be traversed. "On the left side the spleen, under ordinary circumstances, runs no risk of being punctured by inserting the needle well in front of the eleventh intercostal space. Where the right kidney is to be tapped, the needle should be inserted half way between the last rib and the crest of the ileum, between two and two and a half inches behind the anterior superior spine of the ileum. This spot is on a level with the front of the bodies of the lumbar vertebræ, and a needle here passed horizontally inward will be altogether in

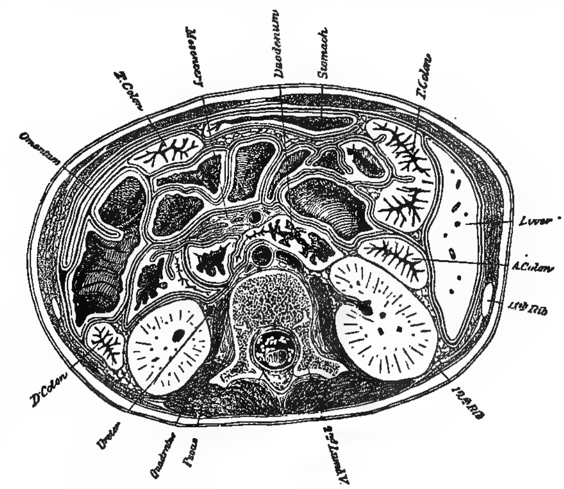

FIG. 14.—Horizontal Section through Second Lumbar Vertebra, showing the Relations of the Kidneys. (From Dwight.)

front of the kidney. It may, however, with safety be conjectured that in any case of hydronephrosis of the right side requiring to be tapped, if the trocar be inserted at this place and directed somewhat forward, the peritoneum and colon will be sufficiently in front to escape injury, the liver will be safely out of reach above and the kidney behind, while the dilated pelvis of the kidney will be tapped at its anterior and lower part" (Mr. Henry Morris).[2]

The kidneys present many varieties both in shape and size. They have been found unequal, lobulated as in the lower animals, or even joined together across the middle line forming the horseshoe kidney, or abnormally placed, the single kidney, for example, having been found entirely on one side of the vertebral column, or even in the lumbar region or pelvis.

The Floating Kidney.—A glance at Fig. 14 will show that the kidney might with no great difficulty be displaced either forward, carrying its peritoneal covering before it, so as to form a mesonephron, or upward or downward. This condition is more common in women than in men. Its presence may be inferred when a reniform tumor is met with in the abdomen, and when the percussion note over one or other lumbar region is clear. The right kidney is more frequently out of place than the left.

The renal arteries are subject to many variations, the

most important being the presence of two arteries on each side entering the kidney at its upper and lower ends. This abnormality should not be forgotten in the operation of nephrectomy. The renal veins pass inward from the kidney in front of the arteries to join the vena cava nearly at right angles. The left renal vein receives the spermatic vein of its own side, an arrangement which has been thought to be the cause of varicocele, and which is accounted for by the history of the descent of the testicle. In fœtal life the left kidney and the left testis lying the one directly above the other, send their emulgent veins to join one another before crossing the middle line. The descent of the testis converts the acute angle at which the left spermatic vein joins the renal into a right angle.

The renal plexus and the least splanchnic nerve supply the kidney. The lumbar pain of kidney disease may be accounted for by the fact that the lesser splanchnic nerves originate from those sympathetic ganglia which are connected with the lower dorsal (eleventh and twelfth) spinal nerves, which supply the skin in the dorsal region. The renal plexus of the sympathetic is derived from the semilunar ganglion, but some of its fibres come from the aortic and the solar plexus. Why does irritation in the kidney, *e. g.*, the presence of calculus, cause pain shooting into the testis? The answer is found in the fact that the spermatic plexus is connected with the renal plexus. The deadly sickening sensation experienced when the testis receives a blow, or is squeezed, is due to the connection of the spermatic nerves with the solar plexus, by means of the aortic plexus as well as by the above-mentioned means of communication. In fact, the testis belongs to the abdomen. This so-called "testicular" sensation is merely what would be experienced if any of the solid viscera were subjected to sudden severe pressure.

The Umbilical Region.—The transverse colon crosses the upper part of the region inclining upward toward the spleen. The third part of the duodenum lies behind the colon in the middle line crossing the aorta beneath the superior mesenteric artery. The small intestines are disposed at the sides of the space, being suspended in the mesentery which lies close to the anterior wall of the abdomen, with the great omentum in front of it. The abdomen is very shallow in the umbilical region. In a tall, muscular man, the distance between the skin and the lumbar vertebræ in the vicinity of the navel is but about two inches or less. The bodies of the lumbar vertebræ project, and, as it were, push the small intestines to one or other side. In the retracted abdomen a penetrating wound may reach the backbone without necessarily injuring the intestine, or, in fact, any structure except the abdominal wall, the omentum, and the peritoneum. Hennen records the "recovery of a soldier who had been shot through the abdomen by a ramrod, which passed in anteriorly and actually stuck in one of the transverse processes of the vertebræ, from which it was not disengaged without the application of some force." Green records a fatal case of impalement: a spike passed through the abdomen and deeply indented the third lumbar vertebra, after having torn the common iliac vein; none of the viscera were injured. A needle pushed horizontally into the abdomen at the umbilicus will most likely wound the great omentum, the transverse colon at its lowermost part, pierce the mesentery, possibly touch the superior mesenteric artery, the aorta, and penetrate the disk between the third and fourth lumbar vertebræ.

In connection with the umbilical region, the great omentum and the mesentery may be considered in their medical and surgical relations. The gastro-colic, or great omentum, is commonly described as consisting of the two layers of peritoneum continued from the anterior and posterior walls of the stomach downward to the lower part of the abdomen, where they are reflected backward and pass upward, the two posterior layers to separate and to enclose the transverse colon. The omentum consists, therefore, of four layers of serous membrane, containing fat, which varies in amount according to the quantity of adipose tissue present generally in the individual. The great omentum is frequently the protruded viscus in herniæ, more especially in those occurring at or near the umbilicus; in some cases it envelops the protruded intestine, and forms a sac for it. The mesentery encloses almost the whole extent of the small intestine, and attaches it to the back of the abdomen, supporting its vessels and nerves. The duodenum is not contained in the mesentery; its first part is enveloped like the stomach, of which it is really the continuation; the second part is covered by peritoneum but in front, while the third part, that which crosses the abdominal aorta, lies between the layers of the transverse mesocolon, and then beneath the superior mesenteric vessels. The mesentery, after surrounding the jejunum and the ileum, is attached to the spine at the left side of the body of the second lumbar vertebra, and extends downward, from left to right, to the sacro-iliac joint; between its two layers are found the trunk and branches of the superior mesenteric vessels, branches of the sympathetic nerves, lymphatic vessels and glands; of the last the largest surround the superior mesenteric

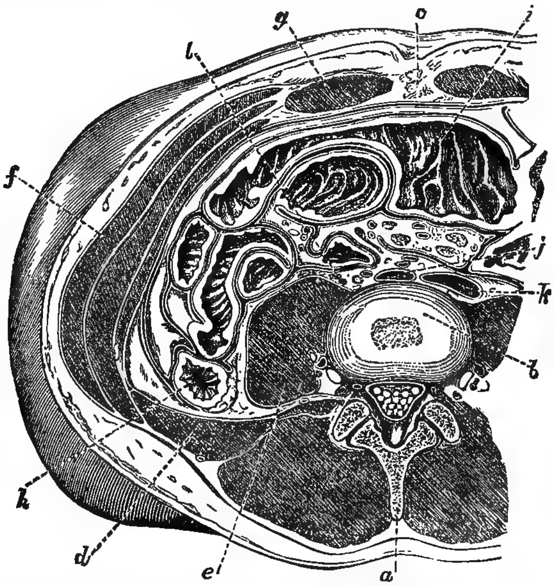

Fig. 15.—Horizontal Section through the Body at the Level of the Umbilicus. (After Braune.) *a*, Spine of fourth lumbar vertebra; *b*, disk between third and fourth vertebræ; *c*, umbilicus; *d*, quadratus lumborum; *e*, psoas; *f*, external oblique, with internal oblique and transversalis beyond; *g*, rectus; *h*, descending colon; *i*, transverse colon; *j*, aorta; *k*, inferior vena cava; *l*, ureter.

artery. Inflammatory conditions of the intestines give rise to glandular enlargements, which are, in fact, buboes, and act as buboes do. In some cases, absorption not being completed, the glands shrink into hard nodules, and in typhoid fever those which receive the absorbents from the lower part of the ileum are enlarged and in rare cases suppurate. It must be remembered that enlarged mesenteric glands may produce anomalous abdominal symptoms by pressure upon vessels and nerves.

The ileum, as compared to the jejunum, is narrower, its coats are thinner and paler, and its valvulæ conniventes are smaller. A given length of jejunum weighs more than the same length of ileum, consequently the ileum is more frequently intussuscepted. The jejunum and the ileum vary greatly in their liability to ulceration, the jejunum being rarely or never diseased; hardly a single instance of primary ulceration of this bowel has been recorded, while the ileum is remarkably liable to disease. Meckel's diverticulum is a protrusion of the intestinal wall, which is often met with opposite the umbilicus; it is all that is left of the omphalo-mesenteric duct which connected the yelk-sac with the fœtal

intestine; the persistence of this structure is thought to be the origin of umbilical rupture.

The Left Lumbar Region.—The relation of parts in this region does not materially differ from that in the right lumbar region. By an opening in the left loin the descending colon may be reached, and that without wounding the peritoneum, for the gut lies up against the outer edge of the quadratus lumborum, the peritoneum covering its anterior portion only. The extent of gut uncovered by serous membrane varies considerably, but on the left side the existence of a mesocolon is less likely than on the right. The operation generally known as lumbar colotomy is performed in this way: The colon is first to be mapped out. Find the centre of the iliac crest, take a point half an inch behind it, and from that point draw a vertical line upward to the margin of the ribs. After this line has been marked with ink, an incision about four inches long is made diagonally downward across its centre; the mid-point of the incision should correspond to the centre of the line. The muscular walls of the abdomen are then divided in such a manner that the extent of division at the bottom of the cut should correspond with that at the surface, lest the surgeon should have to hunt for the gut at the bottom of a conical pit. The fat surrounding the posterior part of the colon will then be found, its thickness depending on the fatness of the patient. On its division the colon will be found. The intestine is then seized, stitched to the margins of the wound and, lastly, opened. The parts divided in the operation are: 1, Areolar tissue; 2, the latissimus dorsi at the posterior part of the incision; 3, the external oblique muscle toward the anterior third; 4, the internal oblique, 5, the origin of the transversalis and the fascia lumborum; 6, occasionally the quadratus lumborum; 7, the layer of adipose tissue which covers the intestine; 8, the colon.

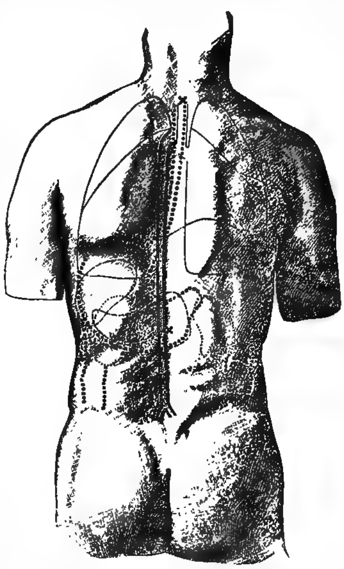

Fig. 16.—Posterior View of the Trunk, showing the Relative Positions of the Principal Thoracic and Abdominal Viscera. (From a drawing by R. J. Godlee.) The trachea and lungs are indicated by thin lines; the aorta by thick lines; the liver, pancreas, and spleen by broken lines; the œsophagus, stomach, and descending colon by thick dotted lines, and the kidneys by thin dotted lines; × ×, seventh cervical and first lumbar spines.

The Right Iliac Region.—The cæcum rests upon the iliacus and the psoas, occupying the right iliac fossa. The peritoneum covers it in front and laterally; posteriorly it is connected with the subjacent fascia by a quantity of loose connective tissue, and is in relation with the nerves of the lumbar plexus. The extent of the serous covering varies greatly. At times there is a mesocæcum, but cases are reported where this mesocæcum was long enough to allow the cæcum to enter an inguinal hernia. The structural peculiarities and the anatomical relations of the cæcum are specially favorable toward the occurrence of accumulations of the solid and liquid contents of the intestine, which lead to the production of pressure symptoms. A cæcum full of hard matter has been known to cause ulceration of large blood-vessels, while pressure on nerves has given rise to retraction of the testis. Accumulations, too, are likely to set up inflammation of the wall of the intestine ending in perforation and the escape of fecal matters into the loose areolar tissue which lies between the posterior wall of the abdomen and the cæcum. Pus formed in this region can work its way along the back part of the abdomen, either perforate or pass behind the diaphragm, enter the pleural cavity, or finding its way into a bronchial tube be the cause of fæcal expectoration. The pus in perityphlitis may take a downward course, passing into the pelvis and perforating the rectum, or out of the pelvis along the pyriformis muscle presenting itself in or below the buttock, or above Poupart's ligament, or below it travelling along the psoas and iliacus muscles.

The vermiform appendix proceeds from the left side of the lower and posterior part of the cæcum, to which it is attached by a mesentery; the latter being in some cases unusually long allows the appendix to hang into the pelvis. The attachment of this free end is a common cause of strangulation by adhesion; foreign bodies finding their way into this little diverticulum set up an inflammation which is often the starting-point of a general peritonitis.

It has been observed in fatal cases of perforation of the appendix vermiformis that, though the concretion is lodged in the middle or upper part of the appendix, yet the perforation is found at the end. This has recently been explained on anatomical grounds by Dr. Fenwick in his recent lectures "On Cases of Difficult Diagnosis," in the *Lancet*, December 6, 1884. "Now the appendix is supplied with blood by means of a small mesentery of its own, which sometimes terminates before the extremity of the process, so that the end must derive its nutriment from the blood-vessels of the part nearer to the cæcum, and, under such conditions, any acute inflammation or ulceration that obstructs the circulation must tend to rapid disorganization of the structures. That this is by no means an uncommon cause of the perforation is shown by the fact that in the majority of cases the perforation is found at the extremity, and very rarely near to the cæcum."

The ileo-colic valve prevents regurgitation into the small intestine, the colon being usually the part of intestine distended in tympanites.

The Hypogastric Region.—The bladder surrounded by small intestine occupies the lower and central part of this region. (See Pelvis.) It is commonly stated that this organ comes into the abdomen merely when distended. In a vertical median section of a frozen body, that of a tall, thin man, I found the bladder occupying a considerable space in the abdomen above the symphysis pubis; a horizontal section at the top of the symphysis would have almost divided the organ into equal parts.

The Left Iliac Region.—The sigmoid flexure is loosely connected by a mesocolon to the abdominal wall, so that its position is by no means constant. Occasionally it is found upon the right side, the intestine having crossed the abdomen completely before making its downward bend. The colon is narrowest just at the sigmoid flexure, a part often the seat of cancerous stricture, and a part more liable to obstruction by twist or volvulus than any other of the whole tube. The ureter, the spermatic and iliac vessels lie beneath the sigmoid flexure; hence an overloaded condition of the lower part of the intestine has been thought to have been the cause of varicocele as well as of milk leg. Recently the iliac vessels have been compressed by means of a lever introduced per rectum, for the purpose of controlling hæmorrhage in amputations of the hip (Davy).

The Abdominal Walls.

The lateral cutaneous branches of the lower intercostal nerves, five or six in number, supply for the most part the skin of the abdomen. After penetrating the muscles they lie beneath the fat, and divide into anterior, lateral, and posterior branches. The largest of the cutaneous branches is that given off by the twelfth dorsal nerve, which is found near the iliac crest. The first branch from the lumbar plexus, the ileo-hypogastric, by its iliac branch supplies the skin over the highest part

of the iliac crest, and, by its hypogastric branch the surface over the region of that name. The inguinal branch of the ileo-inguinal nerve supplies the skin on the inner side of the groin, as well as that upon the scrotum and penis in the male, or labia in the female, communicating with the inferior pudendal nerve. Near the middle line of the abdomen the anterior cutaneous branches of the dorsal nerves make their appearance through the deep structures.

In the clinical study of spinal disease, the knowledge of the distribution of these nerves becomes of very great importance. One of the earliest symptoms of caries of the vertebral column is an ill-defined superficial pain extending around the trunk, more severely felt upon one side than another, taking up its position most frequently upon the chest, the epigastric, or the umbilical region. Careful mapping out of the painful area might lead to detection of the exact point of disease in the spine. In spinal-cord affections the seat of the lesion may be discovered by a careful study of cutaneous reflexes. Irritate the skin in the epigastrium, a dimpling on the corresponding side of the region is the common result. The mechanism of the reflex act is in such a case perfect. Persistent absence of such action points to disease in the dorsal part of the cord high up, for these epigastric cutaneous nerves are derived from the fourth to the sixth or seventh dorsal nerves. Similarly, loss of skin reflex over the abdominal surface, between the margin of the ribs and Poupart's ligament, is evidence in favor of a lesion lower down in the cord, this area being supplied by the branches of the eighth to the twelfth dorsal nerves. Girdle sensations, when felt in the line of distribution of the abdominal cutaneous nerves, similarly indicate lesion in the lower half of the dorsal part of the cord corresponding externally to that space between the upper border of the fifth dorsal spine (seventh dorsal nerve) and the lower border of the tenth dorsal spine. "Girdle sensations may be felt at different levels, the umbilicus corresponding with the tenth dorsal nerve, and the ensiform area with the sixth or seventh dorsal nerve" (Bastian). When the lumbar part of the cord is involved there are no girdle pains.

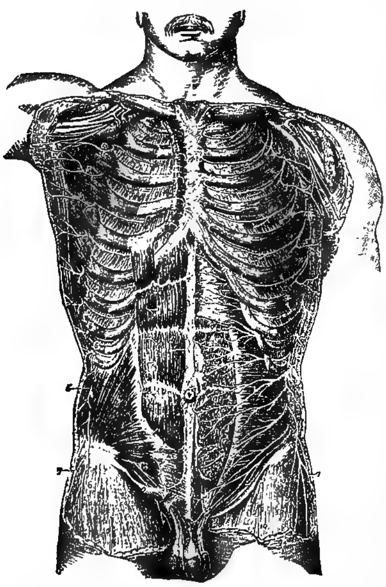

FIG. 17.—View of the Anterior Divisions of the Dorsal and some of the other Spinal Nerves from Before. (From Hirschfeld and Léveillé.) The pectoralis major and minor muscles have been removed; on the right side, the rectus abdominis and internal oblique muscles are shown.

The blood-supply of the skin of the abdomen is derived from the intercostal arteries which accompany the nerves, and from those branches of the femoral which pass from below upward—the superior external pudic, the superficial epigastric, and the superficial circumflex iliac. Superficial branches of the internal mammary and deep epigastric are found joining these. The superficial abdominal veins correspond in extent and direction with the arteries; they appear to be valveless, inasmuch as the blood seems to run both ways in them. When enlarged by obstruction of the vena cava[3] the veins transmit the blood upward, while in the normal condition of parts, the direction of the current is downward.

There are no lymphatic glands in the abdominal wall. The superficial vessels of the lower part of the trunk, together with those of the gluteal region, perineum, and genital organs empty themselves into the superficial inguinal glands, which are arranged in two sets, a superior set above Poupart's ligament, an inferior or vertical set below it. The former are ranged in a line parallel to the ligament, the latter surround the saphenous vein and receive the lymphatic vessels of the lower limbs. The superficial lymphatics of the upper part of the abdominal wall, commencing about the level of the umbilicus, ascend to the lowest glands of the axillary set, which lie upon the serratus magnus, near the long thoracic artery at the lower border of the pectoral muscle. The line of glands upon the subscapular vessels receive the lymphatics of the back of the abdomen.

THE ABDOMINAL FASCIÆ.—The superficial fascia of the abdomen consists of two layers: 1. A subcutaneous layer in no way distinct from that covering the body generally. This layer contains much fat, even in thin subjects. 2. A deep layer, which in many anatomical and surgical works is spoken of as the superficial fascia of the abdomen, but which is more commonly known as Scarpa's fascia. This fascia contains much elastic tissue, which in the lower animals is highly developed, forming the tunica abdominalis, a structure which aids in the support of the viscera. Scarpa's fascia lies in direct apposition with the aponeurosis of the external oblique muscle of the abdomen, to which it is attached by very loose connective tissue which would easily allow the passage of pus. About the umbilicus the fascia is adherent to the other abdominal fasciæ. In the middle line inferiorly it gives off that fibro-elastic band, the ligamentum suspensorium, and becomes continuous with the superficial fascia of the penis as well as with the dartos of the scrotum. On the front of the groin Scarpa's fascia descends over Poupart's ligament, and becomes attached below to the fascia lata of the thigh; at the external abdominal ring it becomes prolonged over the cord along with the subcutaneous layer, which, as it approaches the scrotum, loses its fat. The united layer finally forms the musculo-fibrous bag, the dartos of the scrotum. The attachments and connections of this fascia explain the course taken by extravasated urine into the perineal tissues beneath the deep layer of the superficial fascia of the perineum. The membranous is the part of the urethra which usually gives way, the urine leaks between the layers of the triangular ligament, where the canal is weak and where it is least supported by neighboring structures. The extravasated urine afterward works its way through the anterior layer of the triangular ligament at the point where it is perforated by the urethra. The fluid is in this way now situated between the deep layers of the superficial perineal fascia;

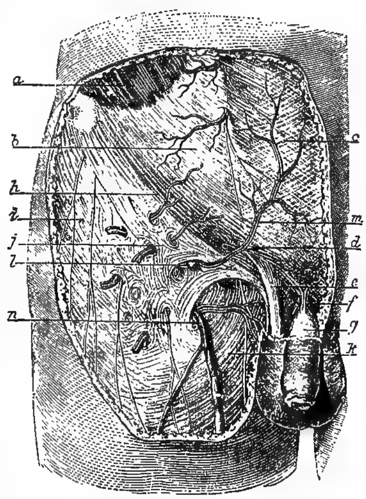

FIG. 18.—Superficial Plan of the Region of the Groin. (After Léveillé.) *a*, *b*, The obliquus externus and its aponeurosis, which latter, at *c*, crosses the fibres of its fellow of the other side, and at *d* forms the pillars of the ring; *e*, spermatic cord; *f*, *g*, suspensory ligament of the penis; *h*, crural arch; *i*, fascia lata; *j*, fascia cribriformis; *m*, superficial epigastric artery.

it cannot pass into the ischio-rectal fossa, because the triangular ligament winds around the transversus perinei muscle, to become directly continuous with the deep layer of the superficial fascia; nor can it run down the thighs, because these two layers of fascia are firmly adherent to the ramus of the ischium and pubes. The only path left for the urine is upward into the scrotum, for the dartos is continuous with the deep layer of the superficial perineal fascia. The scrotal and penile tissues are now infiltrated. The leakage increases. Where next? The dartos is continuous with both the abdominal fasciæ, the urine passes readily under them, and mounts up on the surface of the belly. Why does not gravity exert its influence then, and allow the fluid to run into the thighs? This move is prevented by the attachment of Scarpa's fascia to the fascia lata just below Poupart's ligament.

The Abdominal Muscles.—The tendinous intersections of *the rectus* have been mentioned as being in some persons perceptible during life. The most constant of these inscriptions are one at the umbilicus, another on a level with the tip of the ensiform appendix, and a third immediately between the first two. The rectus is a polygastric muscle, each intersection receiving a separate nerve supply and being, under certain circumstances, capable of independent action. Phantom tumors are found in the rectus more frequently than in any other muscles, and are very difficult to recognize. Abnormal conditions of the nerve supplying one segment of the muscle will develop a tumor which is "firm, nearly hard, constant in its characters and place, often painful, and distinctly pulsating like an aneurism" (Paget). The sheath of the rectus is formed by the aponeurosis of the neighboring muscles. Posteriorly the sheath is deficient at its upper end, where the muscle is in contact with the cartilages of the ribs, and inferiorly for a space corresponding with its lower fourth. These surfaces of the rectus which are devoid of covering are penetrated above by the internal mammary, and below by the deep epigastric arteries. The sheath keeps the muscle in its place, and by strengthening the abdominal wall prevents the more frequent occurrence of hernia. Possibly the deficiency of the sheath at the lower fourth of the muscle intensifies its expulsive action upon the uterus and the bladder. Pus at times forms in, and is limited by, the sheath of the rectus. In the reduction of a knuckle of intestine in abdominal wounds through this muscle, the surgeon must be careful lest he push the gut into the rectus sheath, and so defeat the object of his manipulations.

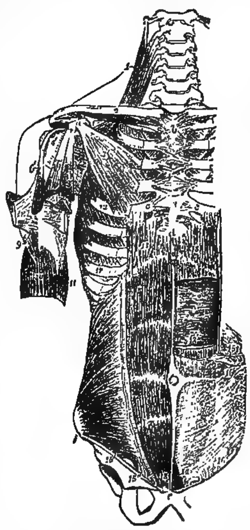

Fig. 19.—Deep Muscles of the Forepart of the Trunk and Shoulder. (From Quain.) *e*, Symphysis pubis; *f*, anterior superior iliac spine; 12, origin of the serratus magnus; 13, 13, on the right side, the rectus abdominis; on the left side, 13′, 13′, the divided ends of the same muscle, a portion being removed; 14, pyramidalis muscle exposed on the left side; 15, on the right side, the internal oblique muscle; 15′, origin of its lower fibres from the deep surface of Poupart's ligament; 15″, conjoined tendon of the internal oblique and transversalis.

The External Abdominal Oblique takes the direction of the external intercostals of the thorax; it arises from the outer surface of the eight lower ribs by serrations, four or five of which interdigitate with the serratus magnus, and three or four with the latissimus dorsi. The lowest digitation is connected with the cartilage of the twelfth rib. The posterior fibres, almost vertical, are inserted into the external margin of the crista ilii for about the anterior half of its length. The rest of the muscle inclines forward, and is attached to the whole length of Poupart's ligament below, and in the mid-line of the body joins with its fellow of the opposite side. The posterior border of the external oblique is free. At its lower end it occasionally forms, with the iliac origin of the latissimus dorsi and the ileum, a triangular space known as the triangle of Petit, through which lumbar hernia has been known to protrude. The aponeurosis of the external oblique occupies the front of the abdomen anterior to a line drawn from the eighth rib to the forepart of the crest of the ileum; it is narrower in the middle than at either upper or lower end, and joins the linea alba along the middle line of the body. The aponeurosis is thin above, and is continued from the surface of the rectus to form the covering of the pectoralis major and the ribs; as it descends it increases in strength, and its fibres become gathered together in a firm band between the spine of the pubes and the iliac crest forming Poupart's ligament. The aponeurosis splits just above the spine to allow the passage of the spermatic cord. The external abdominal ring will be described in connection with the groin.

The course of the fibres of *the internal oblique* is directly the reverse of those of the external oblique. Its aponeurosis lies directly on the transversalis muscle, and in the neighborhood of the symphysis pubis is not to be separated from it. Between the internal oblique and the transversalis will be found the lower intercostal, the ileo-hypogastric, and ileo-inguinal nerves, as well as the branches of the circumflex iliac artery.

The Cremaster, a suspensory muscle, consists of fibres continuous with those of the lower border of the internal oblique. Externally it arises from Poupart's ligament below, and in part beneath the internal oblique. Internally it is attached to the front of the pubes, rejoining the tendon of the internal oblique. Between these points of attachment it forms loops which descend in front of the spermatic cord, and of which some few reach the level of the testicle. These looped bundles of fibres are united by areolar tissue, so as to give rise to a covering on the front of the cord, the cremasteric fascia. The cremaster is subject to many variations. In some cases but a few fibres are seen descending from its outer attachment, in others the muscle not only lies upon the cord, but behind it and upon its sides. The action of the cremaster is to raise the testis. The muscle is supplied by the genital branch of the genito-crural nerve, whose cutaneous division supplies the skin on the upper part of the thigh. Irritation of the skin in this region ought to be followed by slow retraction of the testis. This cremasteric reflex is best seen in the young. Its absence is a point in the evidence of the existence of disease or injury of the cord above the first and second lumbar nerves. The presence of these reflexes (plantar, cremasteric, abdominal) is proof that the reflex path through the cord is not seriously interrupted, but we cannot simply infer from their absence that this path is impaired. The reflex excitability of the cord varies much in different individuals, is always greatest in early life, and is often lessened in the old (Gowers).

The fibres of *the transversalis* run directly backward and forward. Posteriorly its aponeurosis is in connection above with the lower border of the last rib, and with the lumbar fascia, the strong aponeurotic envelope of the quadratus lumborum and the erector spinæ, which is attached to the spines of the transverse processes and sides of the bodies of the lumbar vertebræ, and below to the ileo-lumbar ligament. The transversalis on its inner surface is lined by the transversalis fascia, which separates it from the peritoneum.

The abdominal cavity is lined by *the transversalis fascia*, which is thick below, but as it approaches and covers the diaphragm it becomes thin. At the outer part of Poupart's ligament it is attached to the periosteum of the crest of the ileum where it comes into contact with the iliac fascia, and passes below Poupart's ligament at its middle, forming the anterior part of the sheath of the femoral vessels and of the femoral canal. Pus beneath the transversalis fascia is limited; the

outer edge of the psoas prevents its going backward; the attachments below of the fascia to the bone and Poupart's ligament prevent its passing downward; gravity prevents its ascent. Such abscesses most commonly point just above the iliac crest or Poupart's ligament. It must be remembered that the transversalis fascia furnishes one of the coverings of the cord, so that pus may force its way along the inguinal canal and cause its distention.

If the reader will look at Fig. 20 he will perceive that, in front of the quadratus lumborum, there is a strong fascia—*the lumbar fascia*—continuous externally with the origin of the transversalis, that there is a layer behind the muscle, between it and the erector spinæ, and that this last muscle itself derives a covering from the spine of the lumbar vertebræ. For purposes of description the lumbar fascia has been divided into three layers. The first extends over the anterior surface of the quadratus lumborum, arising from the root of the transverse processes of the lumbar vertebræ, and is continuous at the outer edge of the quadratus with the origin of the transversalis. The middle layer is the tendon of the transversalis, arising from the tips of the transverse processes in the lumbar region; it lies between the quadratus and the erector spinæ, and gives origin to the posterior aponeurosis of the internal oblique. The posterior layer is attached to the spines of the vertebræ, covers the posterior surface of the erector spinæ, and becomes on its outer side continuous with the middle layer. That layer of the lumbar fascia which covers the anterior surface of the quadratus lumborum gives origin to the tendinous margin of the diaphragm, and is called the ligamentum arcuatum externum. The posterior layer gives origin to the latissimus dorsi and serratus posticus inferior.

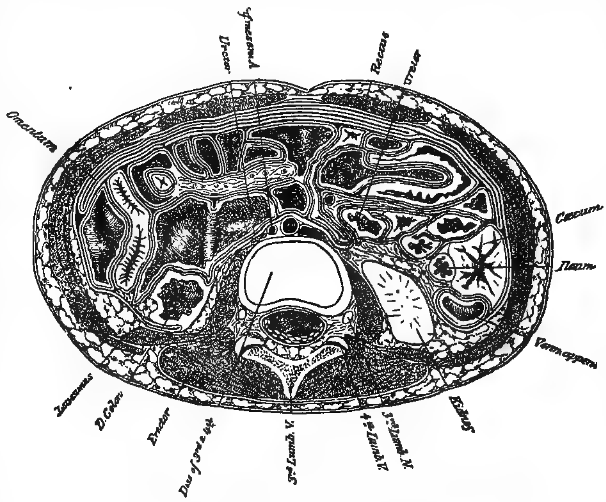

FIG. 20.—Section through the Intervertebral Disk, between the Third and Fourth Lumbar Vertebræ. (Dwight.)

LUMBAR ABSCESS.—Abscess in connection with disease of the vertebræ points either in the lumbar region (lumbar abscess) or in the groin (psoas abscess). The course of pus in lumbar abscess is determined by the arrangement of the fasciæ and muscles at the back of the abdomen. Its common course is outward, separating the erector spinæ from the quadratus, or perforating the latter and reaching a point beyond the margin of the erector. Here, covered in by the lumbar aponeurosis, it may form a considerable swelling in the flanks, or, working its way into the origins of the abdominal muscles, slip between them and point upon the groin above Poupart's ligament; the pus being guided along the course of the nerves. The twelfth dorsal nerve and the first lumbar artery, after crossing in front of the quadratus at its outer edge, perforate the posterior aponeurosis of the transversalis, and enable the pus to reach a point between the latissimus dorsi and the external oblique. The ilio-hypogastric nerve takes a similar course.

PSOAS ABSCESS.—The anterior lamella of the fascia lumborum lies in front of the quadratus, and at its outer edge forms the origin of the transversalis abdominis. The psoas muscle lies to the inner side of the quadratus; its fascia is a distinctly enclosing sheath, which below is continuous with the iliac fascia, and both pass under Poupart's ligament. When abscess forms in the neighborhood of the spinal column, especially in the lumbar region, it usually collects under this sheath, in many cases occupying it, splitting up and absorbing the psoas, and passing downward beneath Poupart's ligament, so as to point in the groin, usually to the outer side of the vessels. In other words, a psoas abscess follows the course of the anterior crural nerve, which lies in the structure of the psoas muscle. The psoas fascia is continuous with that covering the iliacus, the latter passing over the muscle beneath Poupart's ligament, to form the posterior layer of the sheath of the femoral vessels. It should be noted that the common and external iliac vessels are above the iliac fascia, and rest upon its abdominal surface, while the anterior crural and other abdominal nerves are situated within the fascia.

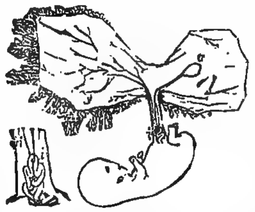
FIG. 21.—Sketch of the Human Embryo of the Tenth Week, showing the Coil of Intestine in the Umbilical Cord. (From Quain.) The amnion and villous chorion have been opened, and the embryo drawn aside from them. The vitello-intestinal duct with the omphalo-mesenteric vessels are seen projecting into the rudimentary umbilical cord.

THE UMBILICAL RING.—The umbilical ring is the opening through which in embryonic life communication was kept up between the uterus and the fœtus. At that period there passed through it the omphalo-mesenteric duct, the omphalo-mesenteric vessels, the tubular communication of the bladder with the allantois, called the urachus, the umbilical arteries and veins. The omphalo-mesenteric duct was once wide, and at about the third month of utero-gestation contained a coil of the small intestine. Thus, as a matter of fact, umbilical hernia was at that period of life a normal condition. The incomplete shrinking of the canal allows this form of rupture to take place, and accounts for the fact that it is in the vast majority of cases congenital. Acquired umbilical hernia occurs most commonly in very stout persons or in those women who have borne many children, owing to the stretching to which the linea alba has been subjected. In such cases protrusion of the omentum nearly always occurs, either through the ring itself or through the abdominal wall in the immediate neighborhood of it. A congenital umbilical hernia usually disappears as the child grows, but acquired ruptures of this kind are sometimes very large and frequently irreducible. The coverings of an umbilical hernia consist merely of skin and expanded linea alba. The peritoneum of the hernial sac is very thin, and tends, especially in a case of long standing, to be firmly adherent to the hernial opening, so that in herniotomy it must of necessity be opened. In certain cases the omphalo-mesenteric duct is closed in but part of its extent. The intestinal end of the duct remains wide, forming the diverticulum of Meckel, but in rarer cases the extremity of the diverticulum is connected with the umbilicus. Cases are on record of the passage of fæces from the navel, as well as of bile and even gall-stones.

Incomplete obliteration of the urachus accounts for those cases in which urine passes from the bladder through the umbilical ring. An exaggeration of this condition constitutes what is known as extroversion of the bladder. The abdominal wall from the navel to the pubes is deficient; the posterior wall of the bladder with the opening of the ureters becomes visible, being

pressed outward by the weight of the superincumbent intestines.

R. L. MacDonnell.

[1] Lectures on the Principles and Practice of Surgery, by Sir Astley Cooper. London, 1830.
[2] London Lancet, March 15, 1884.
[3] See case reported by Mr. Moullin. Lancet, vol. i., 1884.

ABDOMEN, Wounds and Contusions of.—Injuries to the abdomen will in this article be considered under the heads of: 1. Contusions of the abdominal parietes. 2. Injuries to the viscera. 3. Superficial wounds of the parietes (without penetration into the peritoneal cavity). 4. Wounds opening into the peritoneal cavity. 5. Wounds opening into the peritoneal cavity, with protrusion of viscera.

1. Contusions of the abdominal parietes may be caused by blows, kicks, falls against protruding bodies, or by heavy bodies falling upon or passing over the abdomen, or by spent balls or bullets. With regard to such contusions, even though apparently slight, we must be careful in treatment and guarded in prognosis. Leaving out of consideration for the present all danger of visceral complication, we cannot always measure the amount of injury to the deeper tissues of the abdominal walls and their peritoneal lining. We may have extensive extravasation of blood between the layers, or such laceration of the muscular or other tissues as to give rise to troublesome sloughing or burrowing. We may have peritonitis, arising either from primary injury to the peritoneum itself, or by extension from superjacent tissues. If extravasation is great, and especially if it is at the same time circumscribed, we shall have fluctuation; but we may have blood in broad, thin layers, which will not give this sensation. We should also observe whether there is any depression indicative of division of muscle. If we find either of the above conditions well marked, it may be necessary to resort to such operative procedure as shall bring them under the next class of injuries, where they will be further considered.

In the treatment of injuries of the abdomen the following general indications are presented: To procure absolute rest, both mechanical and physiological; the arrest of hæmorrhage; the evacuation of pus and other morbid products; the derivation of blood by counter-irritation; to combat collapse and exhaustion. By at once securing absolute rest in the recumbent posture, we shall lessen the tendency to extravasation, promote the repair of the lacerated tissues and their restoration to vitality, and diminish subsequent inflammatory action. Freedom from pain and physiological rest may, if necessary, be induced by opium (gr. j. to ij. every three or four hours), or morphia may be given hypodermically. Minute doses of atropine are often added, to check vomiting; to prevent collapse, ammonia and other stimulants may be administered.

If there is reason to suspect slow extravasation, cold may be applied for a short time, but we must be careful not to lessen too much the vitality of the tissues; and it must be borne in mind that very hot applications are also of great service in the arrest of hæmorrhage. By some it has been recommended to make gentle pressure by means of a bandage and a broad compress of cotton batting, or other light material; this may be of service both in arresting hæmorrhage and securing rest, but it must be moderate.

A rather novel expedient has been resorted to by some practitioners, that of imprisoning blood in the arms and legs by means of elastic bands, so applied as to retard the return of venous blood from them to the trunk, the object being to lessen the amount of blood in hæmorrhage and in congestion or inflammatory action. The trial of this contrivance has not been sufficiently extensive to warrant any positive conclusion regarding it. Hæmostatics may also be given, care being taken not to induce vomiting. As it is of importance to secure prompt hæmostasis, one large dose of acetate of lead, say thirty to sixty grains, may be given, followed by ergot, gallic or sulphuric acid, or hamamelis, in repeated doses. After hæmorrhage has ceased, collections of fluid blood may with advantage be removed by the aspirator.

Should peritonitis supervene, we shall generally have increased and deep-seated pain, aggravated by continuous steady pressure, or by extension and flexion of the thighs; anxious, pinched countenance; tympanites; dry, brown tongue; high temperature; quick, wiry pulse, and vomiting. Although it is always understood that some of the symptoms of a given disease will at times be absent, yet we are so accustomed to look for high temperature in peritonitis that it may be worth while to remark here that cases will occasionally occur, and proceed to a fatal termination, with sub-normal temperature; it is in cases of traumatic peritonitis (with their severe shock) that this is most apt to occur. On the occurrence of peritonitis, the first of the indications stated above is instinctively acted upon, the abdomen being tense, the breathing thoracic, and the legs drawn up to avoid pressure. It is well that greater rest be secured at times by placing pillows or other supports under the patient's knees, relieving the muscles of the thighs and legs. Opium has often been characterized as the "sheet anchor" in the treatment of peritonitis; and the expression is so apt that we may be pardoned for repeating it here. It should be administered freely in the forms before indicated; to it are sometimes added at the outset small doses of calomel, say one grain; besides, atropine, bismuth, and cerium are often given to control vomiting; later on, turpentine may be of service, especially if there is much tympanites, and we are sure that there is no wound of the stomach or intestines. In the early stage of traumatic peritonitis, if there has not been much hæmorrhage, cardiac sedatives may be given. General bleeding has not now many advocates; but, if used at all, it would be in cases of the character just described, and in such cases, too, leeches may be applied to the abdomen.

Counter-irritants and hot fomentations should be constantly applied. A good and very common mode of fomentation is to have two bags, which will cover the abdomen and hang slightly over the hips; they should hold a layer of bran or hops about four inches thick, and should be heated alternately in a steamer the lid of which is not completely closed down. When pain is subdued, they may be replaced by poultices or a layer of cotton batting. Some of these applications should be kept on until pain has been entirely absent for some days, it being borne in mind that peritonitis, whether acute or sub-acute, is very treacherous. (For fuller remarks on peritonitis and its treatment, the reader is referred to the article on that subject.)

To return to the consideration of the tissues of the abdominal walls: if there is subsequently any indication that suppuration is about to take place, light emollient poultices should be applied, and we should watch carefully for the formation of pus and secure its evacuation. If we consider the nature and relations of the tissues of the abdominal parietes, we will see how careful we must be to prevent burrowing of matter or absorption of septic material. The various details of diagnosis, exploration and evacuation of pus, drainage, and aseptic irrigation usual in the treatment of suppurating wounds in general must be here employed. (See article on Wounds.) Attention must also be paid to constitutional treatment: the patient must be sustained by tonics and good nourishment, and care must also be given to the eliminative organs and to the sanitary surroundings. (See Air, Ventilation, Bathing, etc.)

In "Holmes's Surgery," Mr. George Pollock, Surgeon to St. George's Hospital, discusses at length the popular belief in sudden deaths arising from blows on the abdomen, and especially on the epigastrium, without organic lesion: death from such blows is generally attributed to the shock to the solar plexus. Mr. Pollock expresses himself as being very sceptical as to whether such deaths do occur without some organic injury, and is very certain that they are at least very rare occurrences.

2. Contusions and ruptures of abdominal viscera may result from the same causes as contusions of the abdominal parietes. Mr. Erichsen applies the name of "buffer accidents" to a class of cases occurring in railway employés caught between approaching cars. Occasionally such injuries are produced by causes other than external violence; rupture of the gall-bladder from gallstones is a common occurrence, and the writer has in his possession a liver with an extensive laceration from this cause. In this case death resulted from peritonitis; large quantities of blood and small calculi were found scattered throughout the abdomen, two very large calculi being embedded in the liver. Other examples are rupture of the bladder from retention of urine; and perforation of the stomach and intestines from ulceration. There is also in the Museum of the Toronto School of Medicine the spleen of an elderly woman in which the cause of rupture is said to have been fright from the occurrence of a fire in close proximity to the woman's residence.

Rupture of the gall-bladder or of the ductus communis choledochus is almost invariably fatal. The symptoms are great pain in the immediate neighborhood, anxiety, and rapid collapse.

Rupture of either the liver or spleen alone is not necessarily attended with much pain. If the wound is slight it may heal without the occurrence of grave symptoms; if extensive we are very likely to have faintness and collapse from loss of blood and from the injury to the peritoneum; and if the patient survive this stage we will subsequently have from the same causes violent peritonitis with the symptoms before described. Injuries to the spleen are also apt to be followed by secondary mischief. It will be understood that in the remarks made regarding the course of these injuries, they are spoken of without reference to any modifying influence from their being accompanied by corresponding wounds in the abdominal parietes.

Rupture of the stomach, if in a healthy condition, is of rare occurrence. The size of the wound will be modified by the amount of food in the stomach at the time of the accident. Vomiting of blood generally occurs, but not invariably. The injury causes death either from hæmorrhage or from the escaping contents causing fatal peritonitis. Cases are on record in which post-mortem examination has revealed the fact that rupture had taken place between the lines of attachment of the layers of the omentum, death having been delayed for some time and having finally resulted from the formation of pus, which found its way by ulceration, in some cases into the peritoneal cavity, causing great distress and rapid collapse, and in others forming a gastric fistula discharging externally through the abdominal walls.

Wounds of the intestines are the most common fatal lesions of abdominal viscera met with, and will form the subject of a separate article.

In wounds of the kidneys the consequences and symptoms will vary with the position and extent of the wound. In all cases we may have profuse hæmorrhage and troublesome vomiting. If the anterior portion be injured and the peritoneum ruptured, the passage of urine into the cavity of the latter will cause severe peritoneal symptoms; if the posterior portion, we shall have extravasation of the urine into the cellular tissue, followed by extensive suppuration. Bloody urine will be a pretty constant symptom.

Rupture of the bladder will, similarly to wounds of the kidneys, give rise to different results according as it occurs above or below the line of peritoneal reflection.

Emphysema sometimes occurs from flatus finding its way through a rent both in the inner surface of the abdominal wall and some portion of the alimentary canal.

In addition to the general indications of treatment mentioned in the early portion of this article as applicable to all injuries of the abdomen, there is one which is common to wounds of the viscera, namely, to check the passage of the secretions and contents of the viscera into the abdominal cavity, and to divert them out of the body by natural or artificial channels. Full doses of opium, hæmostatics, and the other remedial measures and precautions before referred to will assist us in the first-named direction. Opinion does not yet seem to warrant us in ordinary practice to open the abdominal cavity for exploratory purposes, even with the hope of remedying conditions which we have every reason to believe will otherwise end in death. The following procedures are, however, commonly resorted to when occasion arises: free incisions into the cellular and muscular tissues in the region of the kidneys and bladder, and into the abdominal walls to get rid of extravasated urine, pus, or other irritating materials. We must be careful in making these not to wound the epigastric artery or other blood-vessels of any size. Incision of the lower part of the abdominal cavity has been resorted to by several surgeons to allow of the escape of urine in cases of rupture of the bladder. This has sometimes been effected by an incision below Poupart's ligament. By some, among whom may be mentioned Vincent and Slee, more extended incisions have been recommended, for the purpose of exposing the bladder, removing extravasated blood and urine, cleansing the pelvic and abdominal cavities, removing any foreign body which may be in them or in the bladder, and uniting by suture any rent that may be in the latter. In the last-named step the edge of the wound must be turned in, bringing the peritoneal surfaces in contact, and close sutures used, as in wounds of the intestines (*q. v.*). In wounds both of the kidneys and bladder a catheter, frequently changed or cleansed, must be kept constantly in the bladder for two weeks or more, and for some weeks longer frequent catheterization must be practised.

3. In wounds of the abdominal parietes not entering the abdomen it will be evident, from considerations similar to those already made, that it is of the utmost importance to arrest all hæmorrhage before closing the wound. After carefully cleansing it and removing all foreign material, the mouths of bleeding vessels must be found, and closed by torsion or ligation. If necessary, hot water may be applied to the bleeding surface: all oozing must be stopped. If any muscles have been divided they must be reunited by suture; this, not only for securing muscular action, but so that the weakened abdominal wall may not allow of hernial protrusion. In any case the wound must be brought together by sutures extending to the deepest portion of it; the quilled suture answers well. A compress and bandage may then be applied; carbolized cotton answers well for the compress. It may be necessary to flex the thighs by supporting them with pillows, so as to relieve the wound of tension. Precautions as to rest, position, and other points mentioned when speaking of contusions, must not be overlooked.

4. In wounds opening into the peritoneal cavity our first care, after hæmorrhage has been arrested and the wound cleansed, should be to determine, as far as practicable, and as far as circumstances seem to require, whether there has been any lesion to the viscera. The extent, position, and character of the wound, and the thickness of the abdominal wall, may be such that we are enabled readily to determine whether or not such lesion exists. The nature of the wound and of its producing cause may do us the same service, or we may have protrusion of the viscera, so that they may be readily examined. The question may have been determined in the affirmative by the escape from the wound of feculent matter, of food—partly digested it may be—of bile or of urine, or there may be hæmorrhage from within the cavity; and it is well that the patient should be so turned for a time that the wound may be in a dependent position, so as to allow of the escape of any of the above-named fluids. The duty of the surgeon is clear under each of the conditions above alluded to, and will be described presently.

But supposing that they do not exist, and that there is reason to suspect that there may be injury to the viscera or to some blood-vessel in the abdominal cavity. What is then the proper course? In the days when men ap-

plauded the saying, "Abdominal surgery is abominable surgery," the maxim of giving the poor unfortunate "the benefit of the doubt" was thought to be best carried out by leaving the doubt unsolved. But as the statistics of each succeeding year show a great increase in the percentage of recoveries from operations on the abdomen, and a great increase in the number and extent of such operations, the opinion is now becoming prevalent that there is less risk in doing what is necessary for a proper exploration and cleansing of the abdominal cavity than there is in closing that cavity, while we are not certain but that we are leaving a ruptured viscus or blood-vessel to discharge its contents into it, and produce results described when speaking of rupture of viscera. If there is grave reason to suspect the existence of such a condition, and we cannot otherwise come to a determination, it will be desirable to administer an anæsthetic, enlarge the wound or make another in some suitable position, and examine carefully the viscera in the track of the wound and its neighborhood. In undertaking such an exploration, the air of the room should be made warm and moist. The pouring out of hot water in pans will be of assistance in rapidly providing the heat and moisture. The desirability of this mode of procedure must be very apparent when we consider the serious consequences which may result from overlooking such an injury; and the progress, experience, and results in abdominal surgery in recent years justify such a proceeding.

If there be any discharge of blood or feculent matter, we must not abandon our search until we have found the seat of rupture in the alimentary canal, when it must be treated in the manner to be described in the article on Wounds of the Intestines. The course to be pursued, if there be discharge of the urine, has already been referred to. If there be any hæmorrhage, we must search for its source and ligate with antiseptic ligature any bleeding vessel. The cavity of the abdomen must be cleansed by irrigation and the use of sponges, absolutely clean, freed from sand or other extraneous material, and rendered antiseptic. The irrigation will be with water raised to such a temperature that it will be of blood-heat when discharged into the abdominal cavity; this will be best effected by the nozzle of a syringe passed into the most dependent portions of the cavity, the fluid welling up and escaping from the wound. It is by some proposed to add a little table-salt and white of egg to the water, by others to add a disinfectant; if the latter, then the solution should be very weak, as any portion left is liable to be absorbed. The writer has seen alarming symptoms from a small quantity of solution of carbolic acid retained in the meshes of cellular tissue in a wound. All blood and other extraneous material having been removed, the wound must be closed. The only additional point to be noted here is, that the sutures should pass through the abdominal wall, piercing the peritoneum, say a quarter of an inch from the inner lips of the wound, and these lips being everted so that peritoneum shall be apposed to peritoneum; otherwise, instead of a smooth peritoneal surface presenting inward, there will be the roughened edge of other and wounded tissues: the rule is the opposite of that to be observed for union in a mucous or integumentary surface. The same precautions are now to be observed as in the previous classes of injuries of the abdomen.

5. The viscera most commonly extruded from abdominal wounds are intestine and omentum; sometimes stomach, liver, or spleen. The extruded viscera must be carefully examined, any wounds in them treated as already described, foreign substance adhering to them carefully washed away, bleeding arrested, the viscera returned, and the cavity cleansed and closed as before. If, however, any portions of the viscera are so bruised, lacerated, or strangulated that they will become gangrenous, they must not be returned. If the intestine is in such a condition, an artificial anus may be formed. (See Wounds of Intestine.) In the case of a stomach in a similar condition, if anything at all is done, the formation of a gastric fistula may be attempted by sewing the margins of the wound in the stomach to those of the external wound, peritoneum being apposed to peritoneum. The case of Alexis St. Martin is too well known to be here more than alluded to. In all cases where the stomach is known to have been injured we should, while giving it rest, keep up the patient's strength by nutrient enemata.

Cases are on record where portions of liver and spleen, and even the whole spleen, have been removed, and recovery has taken place.

Portions of injured omentum are frequently removed without ill result, and if there is any doubt about the vitality of any such portion, it should certainly be excised, the omentum being firmly ligated on the proximal side of the injured portion, either by a single ligature or by a double one passed through the substance of it, the halves being ligated separately. Some surgeons use whip-cord, and leave the stump in the wound; but the preferable way is to use stout carbolized catgut, and return the stump into the abdomen.

In returning the viscera the part last protruded must be returned first, and so on, little by little, until the whole mass suddenly slips in. It is sometimes necessary to enlarge the opening slightly or divide constricting bands. This must be done carefully, as in operations for hernia. If the intestines or stomach be much distended with flatus an aspirating needle may be used. Viscera should not be exposed longer than is absolutely necessary; and, if any delay occur, they should be covered by cloths dipped out of warm water. The same is true of exposure of the abdominal cavity itself.

While there are such differences of opinion as to the necessity for carbolic spray in abdominal surgery as are exhibited in the views of Mr. Lawson Tait and Professor Lister, for example, it is needless to say that no delay should be incurred in waiting to arrange for it: but the abdominal wound should be closed with all possible despatch, having first been thoroughly cleansed.

Rupture of the diaphragm is attended with sharp pain, and usually with difficulty of breathing. It is generally followed, after a time, by extrusion of some of the abdominal viscera into the thoracic cavity. The signs will vary with the seat of the laceration and the nature of the organs extruded. The impulse of the heart may be heard more to one or other side, according as it is pushed out of place by these extruded viscera. In the lower part of the thoracic cavity there will be absence of respiratory murmur and abnormal dulness or resonance, according as spleen or liver in the one case, or stomach or intestine in the other, has been extruded. Death may result from hæmorrhage, peritonitis, pericarditis, or pleuritis, or from strangulation of the viscus involved. Nothing can be done beyond following out the indications referred to in the first part of this article.

Further consideration of injuries to the abdomen and abdominal viscera from explosive missiles will be found in the articles on Gunshot Wounds, Wounds of Intestines, and Peritonitis. *Wm. Oldright.*

ABDOMINAL TUMORS. Interpreting the above title in its broadest sense, the writer designates by it all abnormal abdominal enlargements, whether general or local. Referring the reader to the articles on diseases of the abdominal organs for the morbid anatomy, prognosis, and treatment of abdominal tumors, the writer proposes to briefly tabulate the distinctive etiological and clinical features upon which their practical differential diagnosis may be based. Selecting, in most cases, a prominent tumor of a given organ, he will endeavor to collate those morbid conditions most likely to be mistaken for it, and to contrast their distinguishing physical signs and salient rational symptoms with those of the tumor in question. He will then subjoin a brief description of other tumors, affecting the given organ, which present only remote resemblances to the typical enlargement chosen, and of those possessing no special analogy to other tumors. In other cases, the various tumors of organs will be described without reference to any typical enlargement, and, usually, in the order of their frequency and importance.

In examining abdominal tumors we may employ posture, inspection, palpation, auscultation, percussion, mensuration, rectal injections of fluid or gas, aspiration, and, rarely, exploratory incisions.

The position best adapted to the relaxation of the abdominal walls is that of recumbency, the head being somewhat elevated above the hard, plane surface upon which the trunk reclines, while the thighs are flexed and everted. Complete muscular relaxation may be obtained by anæsthesia. The lateral, prone, stooping, or erect positions may sometimes aid in bringing abdominal tumors into prominence.

Inspection reveals changes in the size, form, and movements of the abdomen. Changes in form may afford important information relating to the local or general character of a tumor. Abdominal enlargements naturally limit the abdominal respiratory movement, or, if painful and tender, cause its complete arrest. Inspection occasionally shows the gastric and intestinal vermicular movements.

By *palpation* evidence is obtained regarding the position, consistency, depth, size, outline, mobility or fixation, smoothness or nodosity, and tenderness or insensitiveness of tumors. Impulses from aneurisms, the hydatid fremitus, and fluctuation are also perceived by the aid of palpation. Palpation should be gently practised in order that no spasm of the abdominal muscles be excited. The ball of the fingers should be horizontally and evenly applied, as pressure with the vertically directed finger-tips may cause pain and muscular contraction. Deep palpation may be best performed by superimposing the fingers of the disengaged hand upon those in direct contact with the abdominal wall. The patient having been then instructed to make a series of efficient expiratory efforts, the fingers are further depressed at the occurrence of each expiration. By this gradual process the fingers may finally even be brought into close contact with the aorta and the vertebral column. An enlarged liver or spleen may sometimes be grasped between the fingers and thumb, the latter resting upon the organ while the former are inserted beneath it. The kidneys may be seized in a similar manner, the fingers and thumb of one hand being applied posteriorly and anteriorly, respectively, to the lumbar region. Vaginal palpation yields information regarding abdominal enlargements originating in the pelvis, and Simon's intrarectal method, combined with external manipulation, enables the examiner to explore almost the entire abdominal cavity. *Auscultation* discloses aneurismal murmurs, friction sounds, the hydatid fremitus, and various intra-uterine sounds. By means of *percussion* the contours of tumors are mapped out and the differential diagnosis between solid, fluid, and gaseous enlargements established. *Mensuration* shows the exact amount of enlargement or diminution undergone by tumors within definite periods. *Fluid or air may be injected* into the large intestine in order that the position of the latter, relatively to renal or ovarian tumors, may be better appreciated. *Aspiration* and analysis of the fluid contained in abdominal tumors, is an auxiliary diagnostic measure of great importance. *Exploratory incisions* are occasionally made for the purpose of ascertaining the character of tumors and of deciding as to the advisability of their removal. The discovery of one abdominal tumor should never deter the diagnostician from instituting a thorough search for other enlargements, similar or dissimilar in nature and affecting the same or other organs. The following order will be adopted in the writer's description of abdominal tumors: 1. Tumors of the Liver. 2. Tumors of the Stomach. 3. Tumors of the Kidney. 4. Tumors of the Spleen. 5. Tumors of the Pancreas. 6. Tumors of the Intestine. 7. Tumors of the Omentum. 8. Tumors of the Bladder. 9. Tumors of the Uterus. 10. Tumors of the Ovary. 11. Miscellaneous Tumors.

1. Tumors of the Liver.

Cancer and other Malignant Tumors.—Cancer of the liver, which is usually secondary to that of the stomach, intestine, uterus, ovary, or mamma, and is of the medullary variety, attacks males and females with equal frequency, occurs, generally, between the ages of forty and sixty, in those possessing an hereditary tendency, and presents the following signs and symptoms: On *inspection*, in advanced cases, the right hypochondrium is ordinarily seen to be unduly prominent, and the respiratory movements of the right side diminished. These signs are absent in cases unattended by hepatic enlargement. On *palpation*, the liver is found unsymmetrically enlarged, extending below the free border of the ribs, and occasionally even reaching beyond the umbilicus. Hard nodules, tender and sometimes umbilicated, are often felt upon its surface, but may be absent in central or colloid carcinoma. The nodules may be soft or fluctuating. By *percussion* the area of hepatic dulness is found to be increased, in advanced cases nearly or quite reaching the iliac crest, occupying the epigastrium, and even invading the left hypochondrium. On auscultation, a friction sound, due to perihepatitis, may be perceived. In rare cases no signs are discernible. *Symptoms.*—Pain, dull and constant, or lancinating and paroxysmal, is either localized in the organ or radiates into the right shoulder, the back, the abdomen, or the lower extremities; sometimes only weight and tension are complained of, and, rarely, no abnormal sensations are present. Hepatic enlargement is usually rapidly progressive. Ascites occurs in fifty per cent. of all cases; hepatogenous icterus is present with almost the same frequency. Gastritis and enteritis may result from portal congestion, or from primary gastric or intestinal cancer; hæmatemesis and melæna owe their origin to the same sources. Hydræmia, subcutaneous ecchymoses, hæmorrhage from mucous surfaces and hæmorrhoids are occasional symptoms. The temperature is normal or subnormal, except in the presence of inflammatory complications. Dyspnœa, painful respiration, and cardiac palpitation result from encroachment upon the intrathoracic space, and from implication of the peritoneum and pleura. The inguinal and cervical glands are sometimes enlarged. Œdema of the lower extremities is a late symptom. Emaciation is ordinarily extreme, the cachexia evident, and asthenia progressive. None of the above symptoms are constant. Other malignant hepatic tumors, as lymphadenoma and sarcoma, present such close resemblances to cancer that their differentiation is rarely possible. *Diagnosis.*—Cancer of the liver may be mistaken for hepatic abscess or hydatids; for amyloid, syphilitic, cirrhotic, and fatty liver; for hypertrophy, hyperplasia, congestion, or malposition of the organ; for obstruction of its ducts; for enlargements of the gall-bladder, right kidney, colon, omentum, stomach, spleen, ovary, or pancreas; for fæcal impaction or abdominal aneurism.

Abscess of the Liver is distinguished from cancer by its smaller average size, its smooth surface, its more rapid development, and its fluctuation; by the absence of ascites, of primary cancer elsewhere, of cachexia and, generally, of jaundice; by the discovery of pus on aspiration, and by the history of residence in a warm climate, of injury to the right hypochondrium, of antecedent pylephlebitis, pyæmia, or ulcerations in the stomach, intestine, or gall-bladder. The discharge of pus in considerable quantity from the stomach, bowels, bronchial tubes, or renal pelvis, or into the peritoneum, pleura, or pericardium, simultaneously with the rapid subsidence of the tumor, is a symptom of great diagnostic import.

Hydatid tumors are globular, smooth, and, when large, fluctuating. They often present the hydatid fremitus. The colorless, saline, non-albuminous, neutral, or alkaline, and occasionally saccharine, liquid withdrawn, the specific gravity of which varies from 1.007 to 1.015, contains echinococci hooklets. Hydatids grow more slowly than cancer, and are unattended by pain, tenderness (unless inflamed), by nodular induration, cachexia, hæmatemesis, melæna, or ascites. Jaundice is rare and fever usually absent. Hydatids may remain latent. The above remarks relative to the rupture of hepatic abscesses apply with equal force to that of hydatid cysts.

The amyloid liver increases slowly in size. It is smooth, indurated, and uniformly enlarged; its edge is sharply defined and its form preserved; it is painless. Icterus, fever, and the cancerous cachexia are wanting. Ascites occurs in one-quarter of the cases, according to Bartholow, and œdema of the lower extremities is apt to precede the hydroperitoneum. The spleen is enlarged; diarrhœa and waxy disease of the kidneys are present. Phthisis, syphilis, protracted suppuration, especially that of bone, or chronic malarial poisoning have pre-existed.

The syphilitic liver, with gummata, presents indurated nodules simulating cancerous ones, but not umbilicated. The organ is smaller than in cancer, and even smaller than the normal liver. There is a history of specific disease; the spleen and lymphatic glands are enlarged; the liver is not tender; icterus and ascites are generally lacking. The progress is slow.

Hypertrophic cirrhosis of the liver causes uniform enlargement. The surface of the organ is smooth, or but slightly granular; there is no tenderness or notable pain; jaundice is usually a prominent feature; ascites is ordinarily slight or absent, but may be marked; the spleen is invariably enlarged. The duration of the disease is greater than that of carcinoma, and there is a history of alcoholic excesses.

Fatty Liver.—The enlargement is uniform and less marked than in cancer or in amyloid degeneration; the surface is smooth, yielding, and insensitive, the border blunted, the shape of the organ preserved; ascites and pain are not present; icterus is rather rare; the spleen is of normal size. The history is that of intemperance in food or drink, of indolence, of phthisis, or of a sedentary life.

Congestion of the Liver.—(a) *Acute Congestion or Active Hyperæmia.*—In this case the organ undergoes uniform, moderate, rapid, and temporary enlargement; it is smooth and resisting; it is generally somewhat painful and sensitive; its normal contour is retained; jaundice is usually, ascites and fever almost always, absent. Among the causes of active hyperæmia are traumatism, malarial and other blood poisons; according to Frerichs, injury to the semilunar ganglia; high temperature, over-indulgence in alcohol and stimulating foods, and suppressed menstruation. (b) *Chronic Congestion or Passive Hyperæmia.*—The etiology of this condition furnishes the key to its diagnosis, and embraces all causes of obstruction to the hepatic circulation. Chief among the latter are dilatation of the right ventricle, with tricuspid insufficiency, due to valvular disease of the left heart, or to an obstructed pulmonary circulation; the latter may be referable to emphysema, chronic pleurisy, or extensive fibroid induration of the lung. Feeble cardiac action and pressure exerted upon the inferior vena cava by mediastinal tumors are other causes. The liver is uniformly enlarged, in the first stage, sometimes to a considerable extent; its surface is smooth and sensitive on pressure, its outline regular, its consistency firm. Icterus is rare; ascites, gastritis, enteritis, hæmatemesis and hæmorrhoids frequent; the liver pulsates; the spleen is enlarged; in the later stages, the liver is reduced in size, having undergone the changes known as "red or cyanotic atrophy." If the chronic congestion be due to *malarial poisoning*, the physical signs are essentially as stated above. The spleen is notably enlarged, there is a history of antecedent malarial disease, and pigment may be detected in the blood. Cerebral disturbances, diarrhœa, albuminuria, and melæna, symptoms incident to melanæmia, are sometimes observed.

Hypertrophy and Hyperplasia of the Liver.—(a) *Leukæmic.*—The enlargement of the organ is marked and symmetrical, the surface smooth and insensitive; the spleen is hypertrophied and the blood presents the pathognomonic characters of leucocythæmia; the lymphatic glands are enlarged; in pseudo-leucocythæmia the liver presents the same physical signs, but the blood does not contain an excess of white corpuscles. (b) *Simple Hypertrophy.*—The liver is simply abnormally large, sometimes attaining twice its normal size in all its dimensions; it is smooth and insensitive. No symptoms attend this form of enlargement, which, according to Klebs, occurs at times in drunkards. According to the same authority, hypertrophy, unattended by hyperplasia and presenting essentially the same physical features, complicates diabetes mellitus.

Malpositions of the Liver.—These may be either congenital or acquired and are ordinarily due to transposition of the organ, to depression from tight lacing and interthoracic diseases, or to upward displacement, occasioned by ascites, excessive tympanites, or abdominal tumors. Relaxation of the hepatic ligaments from pregnancy and chronic peritonitis may, according to Meissner, constitute a predisposing cause. Malpositions will be diagnosticated from genuine hepatic tumors by the fact that the liver preserves its normal size, consistency, and usually its natural sensibility, and by a consideration of the causes operative in each case. A sense of abdominal weight and discomfort is generally complained of. Sometimes the notch separating the right and left lobes can be recognized.

Enlarged Liver from Obstruction of the Bile-ducts.—This is either a temporary or a permanent condition, resulting from a variety of causes, chief among which may be mentioned gastro-duodenitis with tumefaction of the mucous lining of the ducts, impacted calculi, cicatrices following ulceration of the ducts, parasites and tumors growing in the biliary passages, enlarged lymphatic glands, tumors of the stomach, duodenum, omentum, liver, kidney, or pancreas, impacted fæces, contracting peritoneal bands, perihepatitis, abdominal aneurisims, uterine and ovarian tumors. The liver is enlarged in all its dimensions, being smooth, tender on pressure, and painful; the gall-bladder is sometimes distended and sensitive to the touch; jaundice remains long after the disappearance of the obstruction, in cases of temporary occlusion, and is a persistent symptom in permanent closure of the ducts. The enlargement disappears with the removal of the obstacle to the exit of the bile or may give place to atrophy of the liver, if the occlusion be permanent.

Enlargement of the Gall-bladder.—This may be due to distention from the accumulation of bile, of serous fluid, as in *hydrops cystidis felleæ*, of inflammatory products or of gall-stones, and to cancer. In the first two cases there is a history of antecedent biliary colic, the rounded or pyriform shape of the gall-bladder is evident, jaundice and hepatic enlargement are present, except when the cystic duct is alone occluded, the evacuation of the bile may sometimes be effected spontaneously or by careful pressure, and tenderness is localized over the pear-shaped tumor, which is of rapid growth, movable, soft, and fluctuating. Ascites and splenic enlargement are absent. The examination of fluid withdrawn by aspiration will establish the diagnosis and reveal the character of the bladder's contents. If cystic distention be due to calculi, there is generally a history of the passage of gall-stones, and the tumor, although nodular and indurated, is neither painful nor sensitive. It does not increase in size and is not attended by ascites, jaundice, or cachexia. If carcinoma be the cause of the enlargement it can hardly be distinguished from hepatic cancer, unless plainly limited to the gall-bladder. The diagnostic problem is further complicated by the usual simultaneous involvement of the liver.

For the diagnostic features of enlargements in organs other than the liver, most liable to be mistaken for hepatic tumors, *viz.*, cancer of the intestine and omentum, enlargements of the stomach, pancreas, kidneys, spleen, and ovaries, fæcal accumulations, and abdominal aneurisms, the reader is referred to the remarks contained in this article and in that on abdominal aneurisms regarding the subjects just enumerated.

2. Tumors of the Stomach.

Cancer of the stomach, which is almost always primary, is the most frequent of all primary carcinomata. It is, generally, of the scirrhous variety and usually in-

volves the pyloric extremity, lesser curvature, and posterior surface. It, however, attacks the cardiac orifice in about ten per cent. of all cases, and occasionally develops in the greater curvature. It is sometimes of the colloid or cylindrical epithelial variety. It rarely occurs before the fortieth year, is most frequent between the ages of fifty and sixty, attacks males, by preference, and shows a marked tendency to hereditary transmission. *Signs.*—A tumor is discoverable, by palpation and percussion, in seventy-five per cent. of all cases, according to Da Costa, and in eighty per cent., according to Brinton. The tumor is usually hard, nodular, and immovable, varying in size from that of a small hen's egg to that of a man's clenched hand, is ordinarily sensitive to pressure and located somewhat to the right of the median line, between the umbilicus and the free border of the ribs. It may, however, often be detected in the right hypochondrium, sometimes in the left hypochondrium, occasionally even lower than the umbilicus, and, rarely, as low as the anterior-superior iliac spine or the hypogastrium. It is not depressed by forced contraction of the diaphragm. If the pyloric extremity be the seat of the disease those symptoms and signs of gastrectasia, elsewhere detailed, are present. *Symptoms.*—Pain at the site of the neoplasm is rarely absent; it may be lancinating, with paroxysmal exacerbations, or dull and gnawing; when present it is hardly ever intermitting; it often radiates into abdominal regions other than those occupied by the tumor, or into the back, and sometimes possesses excruciating intensity; it is not materially affected by the ingestion of food. Vomiting occurred, according to Brinton, in eighty-seven per cent. of his recorded cases; when the fundus or greater curvature is involved it may be wanting; in cancer of the cardiac orifice emesis is very constant, taking place immediately after the introduction of food, while, in pyloric carcinoma it occurs only after a longer or shorter interval; vomiting does not relieve the pain; the egesta often contain blood, usually in small quantity, presenting the appearance of coffee-grounds; genuine hæmatemesis, such as attends ulcer, is rarely observed. Anorexia and indigestion, emaciation, obstinate constipation, alternating with diarrhœa, flatulence, enlargement of lymph-glands and development of secondary cancerous growths, moderate fever, progressive asthenia, and cachexia complete the clinical history, the end of which is death, usually within a year, although some cases may be protracted to one and a half or two years. *Differential Diagnosis.*—Those enlargements of the stomach most liable to be confounded with cancer are due to chronic interstitial gastritis, to acute circumscribed parenchymatous gastritis, to gastrectasia, and to other malignant growths. Gastric ulcer and chronic diffuse gastritis must also be differentiated from cancer.

Gastric ulcer may be distinguished from carcinoma by the following facts: It is independent of heredity; attacks, preferably, young women; presents no tumor; is not attended by fever, but by pain, which is more violent, more intensified by food, more relieved by emesis, and more frequently intermittent than that of cancer. Vomiting occurs more constantly in ulcer, at a shorter interval after food, and relieves the pain more certainly than in carcinoma; hæmatemesis is more frequent and abundant in ulcer, which may have a longer course than cancer and end in recovery. Anorexia is less constant in ulcer, and enlargement of lymph-glands is not observed. Emaciation and cachexia are not marked; tenderness is localized.

Chronic gastritis is differentiated from cancer by the following points: Pain and soreness are diffused and constant, but slight, and are aggravated by food; emaciation is not marked, and cachexia is absent; vomiting is less frequent, and hæmatemesis very rare; there is no gastric tumor, and no enlargement of the lymphatic glands; there is slight pyrexia, with furred tongue and constant thirst; the course is protracted, sometimes for many years, and may end in recovery.

Chronic Interstitial Gastritis and Hypertrophic Stenosis of the Pylorus.—A discrimination between these comparatively rare diseases and *cancer ventriculi* is not always possible; the etiology, however, presents some points of difference. In the former, or *fibroid induration*, there is no history of hereditary malignant disease, but sometimes one of excessive indulgence in alcoholics; the patients are usually younger than in cancer, their average age being, according to Dr. Brinton, only thirty-four; the course of the disease is longer than in cancer; pain and tenderness are less marked, while hæmatemesis is rare, and the cancerous cachexia absent; the introduction of only small quantities of food causes a sensation of distention, and emesis frequently soon follows; there are no evidences of secondary tumors, and no glandular enlargements; emaciation, from inanition, progresses rapidly; a movable, smooth, slightly sensitive, indurated tumor, presenting the form of the contracted stomach, occupies the normal site of that organ, and yields a less decidedly tympanitic note than the healthy stomach. In *hypertrophic stenosis of the pylorus* a small, smooth, indurated, movable, and more or less sensitive tumor can be felt in the position corresponding to that of the pylorus, while the remainder of the organ gives the signs of dilatation presently to be described. In this case, obstinate constipation and profuse vomiting, long after eating, of partly decomposed aliment, only containing blood in very exceptional cases, but often *sarcinæ ventriculi*, are cardinal symptoms.

Acute Circumscribed Parenchymatous Inflammation of the Stomach; Abscess.—This disease, which is one of great rarity, may be either idiopathic, in which case it occurs preferably in middle-aged men addicted to excesses in drink, or secondary to pyæmia, acute infectious diseases, or hemorrhagic infarction. The abscesses may be single or multiple, acute or chronic; diffuse purulent infiltration of the gastric parieties also occurs, but presents so little resemblance to cancer as to render its present consideration unnecessary. The differential symptoms and signs between abscess and carcinoma are as follows: In the metastatic or secondary variety there is the history of antecedent pyæmia, but the subsequent clinical features are identical with those of idiopathic abscess; in abscess, the access of gastric disease is announced by a chill, which may be repeated at irregular intervals; this is not true in cancer; the temperature is often greatly elevated, reaching 104° or 106° F., while in cancer it is slightly raised, or not at all; the egesta in emesis from abscess do not contain blood as in cases of cancer, but pus in large quantity, in the event of rupture into the stomach; pain and tenderness are often more severe than in cancer, especially if the peritoneum be involved; the course of idiopathic abscess is generally acute, extending, according to Dr. A. Flint, on the average only from two to ten days; the duration of carcinoma is usually many months; the abscess may fluctuate, which is rare in cancer, the latter ordinarily being of the scirrhous variety; sudden subsidence of the tumor, attended by the vomiting of considerable pus, is a strong though not decisive point for abscess; the latter is not attended by the cancerous cachexia, by hepatic disease, or by enlarged lymph-glands.

Dilatation of the Stomach.—This is a source of abdominal enlargement which often results from cancer, but is not very likely to be mistaken for it if dependent upon other causes. According to Kussmaul's classification, it is either hypertrophic, as is the case when the pyloric obstruction leading to the gastrectasia is compensated, or atrophic, when paresis of the muscular walls or uncompensated obstruction exists. Its leading *physical sign* is an unsymmetrical prominence of the left side of the abdomen, occupying, chiefly, the hypochondriac and umbilical regions; the epigastrium is often depressed or flattened; undulatory movements, usually proceeding from left to right, may sometimes be seen, and these exaggerated peristaltic phenomena, which are more distinctly revealed by palpation, occur most frequently after meals. If the stomach be empty, the peculiar gastric tympanitic resonance is elicited over an enlarged area, or if the organ contain solids and fluids, there is flatness below and tympanitic resonance

Abdominal Tumors.

above the level of the fluid, while a splashing sound is obtained by succussion; metallic tinkling, proceeding from the stomach, may be heard if fluid be swallowed by the patient at the moment of auscultation; the exact contours and dimensions of the dilated stomach may be ascertained by Frerich's method of evolving gas within the organ, which consists in the successive introduction of one half drachm of bicarbonate of soda, dissolved in lukewarm water, and of fifteen or twenty grains of tartaric acid, likewise in solution. The leading *symptom of obstructive gastrectasia* is profuse vomiting, at intervals varying from some hours to several days, of partially digested aliment, in process of fermentation and putrefaction, containing *torulæ cerevisiæ* and *sarcinæ ventriculi* in considerable quantities; there is a sense of oppression at the epigastrium, which is only partly relieved by emesis, as the stomach is hardly ever completely evacuated; pyrosis is present, thirst and constipation persistent, and dyspnœa, from pressure on the diaphragm, occasional; the appetite is generally excellent, but emaciation is rapidly progressive; there is no localized indurated enlargement; pain on pressure is slight or absent, unless in cases of acute dilatation; the complexion is often clear; hæmatemesis is very rare, and no glandular tumors are perceptible. In *atonic dilatation* there may be no emesis, but merely epigastric oppression and eructations, sour or tasteless, together with the physical evidences of gastric enlargement and of the continual pressure, within the organ, of a varying amount of fluid and gas; constipation is constant; emaciation and asthenia are less marked than in the former variety. The *diagnosis* may be facilitated by a consideration of the *etiology*, which embraces, for obstructive gastrectasia, *carcinoma ventriculi*, ulcers resulting in cicatricial contraction of the pyloric extremity of the duodenum, fibroid induration of the pylorus, tumors of organs adjacent to the stomach, as of the pancreas, liver, omentum, and gall-bladder; adhesions from old peritonitis, tractions, exerted by hernias and polypi, on the pyloric extremity. Spastic pyloric contraction and the pressure of a wandering kidney are rare causes of obstructive gastrectasia. The chief *causes of atonic dilatation* are, according to Kussmaul, paralysis of the gastric motor nerves, weakness of the gastric muscles from impaired nutrition in fevers and chronic diseases, diminished irritability of the peristaltic nerves or nerve-centres, and reflex inhibition of gastric peristalsis. Habitual over-distention and chronic gastritis are also efficient predisposing causes of atonic gastrectasia. Those tumors of neighboring organs most frequently mistaken for cancer and other tumors of the stomach are enlargements of the left lobe of the liver and of the pancreas, aneurisms, fæcal accumulations, besides tumors of the spleen, right kidney, peritoneum, and intestine. These are described under their respective titles.

3. Tumors of the Kidney.

These may be classified as solid and cystic tumors. The former variety embraces carcinomata and other malignant neoplasms, syphilomata, tubercles, and large calculi. To this class may be appended movable kidney. The chief tumors of a cystic character are pyonephrosis and abscess, hydronephrosis, hydatids, and true cystic degeneration. All of these conditions produce, when sufficiently developed, a lumbar tumor corresponding to the site of the diseased organ, which may be discovered by palpation. The extent of enlargement may be ascertained by percussion, for which the prone position is most favorable. The cystic tumors will often fluctuate, and the fluid character of their contents is demonstrated by the hypodermic needle. An enlarged right kidney may be mistaken for hepatic tumors, for impacted fæcal matter in the hepatic flexure of the colon, for ovarian, pyloric, or omental tumors, and for perinephritic and psoas abscesses. An enlarged left kidney may be confounded with fæcal impaction in the splenic flexure, tumors of the left ovary, and splenic enlargements. A renal tumor may be distinguished from enlargements of the liver by its immobility during deep inspiration, by its position inside of the colon on the right and behind it on the left side, and by its relation to the ribs, between which and the enlargement the palpating fingers may, generally, be inserted during forced expiration. Fæcal masses are in the course of the colon, retain an indentation imprinted by the finger, and are removed by cathartic remedies. Ovarian tumors first appear in the iliac regions and grow upward, are in front of the colon and present other characteristic features elsewhere detailed. Pyloric and omental tumors, as well as perinephritic and psoas abscesses and splenic tumors, present certain distinctive features, for which the reader is referred to the remarks devoted to these subjects.

Solid Renal Tumors.—*Cancer.*—*Symptoms and Signs:* The renal enlargement is either smooth or nodular, indurated or soft, and is sometimes even fluctuating; it is behind the colon, or to its inner side; it is generally sensitive, immobile on deep inspiration, fixed by adhesions, of rapid growth, and often of great size, extending from the lumbar into adjacent regions. Primary cancer is ordinarily unilateral, and does not produce metastases; children under ten years are most often affected, and next in order of frequency persons above fifty years; the disease is usually non-hereditary and primary, especially in children, but may be secondary, arising either by continuity or by metastasis from other abdominal and pelvic carcinomata; albuminuria, alone or with hæmaturia, is frequent; renal hæmorrhage is sometimes profuse; there is intense pain, which occasionally radiates down the ureter or into the lower extremities; the constitutional symptoms of cancer are more or less plainly manifest. *Sarcomata of the kidney* are rare, and present essentially the same clinical features as cancers, except that they rarely occasion hæmaturia. *Renal gummata* do not often attain a sufficient size to be perceived by palpation, are not painful, are coincident with other local manifestations of a general syphilitic dyscrasia, and yield to constitutional treatment.

Renal Tuberculosis.—A renal tumor due to tubercles, when of sufficient size to be accessible to palpation, is ordinarily sensitive, and may be either hard or soft; it is generally nodular, occupies the usual position of the kidney relatively to the colon, and is secondary to tuberculosis of the lungs, vertebræ, testicle, prostate, bladder, or vasa deferentia; it may, however, in rare instances be primary; it attacks males, in the majority of cases, and is more frequently developed, according to Stewart, in the right kidney. The prominent rational symptoms are hæmaturia, pyuria, cheesy and granular detritus in the urine, pain in the kidney, hectic fever, asthenia, emaciation, and possibly *bacilli tuberculosis* in the urine.

Renal Calculi.—One renal calculus, or several calculi, retained in the pelvis may, rarely, attain dimensions even surpassing those of the healthy kidney, thus substituting for the latter a hard insensitive tumor, either smooth or nodular, the differential diagnosis of which is best established by the exclusion of carcinoma, syphiloma, and tubercle, which affections present the signs and symptoms already described. The previous history may furnish valuable evidence of antecedent or existing pyelitis or renal colic.

Movable Kidney.—This form of renal ectopia, sometimes designated by the terms wandering and floating kidney, usually presents itself in hysterical, middle-aged multiparæ, and on the right side. The physical signs are those of a mobile tumor, possessing the form, outline, and peculiar sensibility of the normal kidney, generally located in the hypochondriac or the umbilical region, either behind or to the outer side of the colon. At the normal site of the organ a hollow is observed, and tympanitic resonance is obtained, but the former disappears, and the latter is replaced by the natural dulness if the kidney be forced to assume or spontaneously regain its usual position. Bartholow states that the kidney descends on deep inspiration, ascending again with the ensuing expiratory act. The leading *symptom*, by no means constantly present, is pain, either of a dragging

character and located in the hypochondrium or radiating into the testicle and thighs, and especially severe in walking. Sometimes the pain is very acute, and accompanied with vomiting, headache, rigors, nervous shock, and hæmaturia; in this case the tumor is often swollen and peculiarly tender. The kidney may compress the vena portæ, the vena cava, or the bowel, thus occasioning ascites, œdema of the lower extremities, and obstipation.

Cystic Renal Tumors.—These are pyonephrosis or renal abscess, hydronephrosis, hydatids, and renal cysts, each of which presents a fluctuating nephritic enlargement. The differential diagnosis of these affections may ordinarily be established by a careful consideration of the constitutional symptoms, and by analysis of the urine or of the fluid withdrawn from the tumor.

Pyonephrosis and renal abscess, of sufficient size to produce perceptible tumors, are generally accompanied by local sensitiveness and by the usual constitutional symptoms of suppuration. The enlargement is commonly smooth and globular, rarely nodular, and may attain the size of a child's head. In pyonephrosis the urine voided from the bladder is normal, if complete obstruction of the affected ureter exist, otherwise it contains pus, blood, and epithelial cells; the sudden appearance of the latter, accompanied by renal colic and coincident with rapid subsidence of the tumor, is strongly in favor of pyonephrosis, although the same phenomena may attend renal abscess. The pre-existence of pyelitis or of renal colic, due to calculi, and the demonstration of some condition capable of obstructing the ureter, point to pyonephrosis. An antecedent surgical injury of the lumbar region, followed by the development of a fluctuating renal tumor, the urine long remaining normal, would indicate the existence of renal abscess. Aspiration and microscopical examination of the fluid withdrawn from the tumor demonstrate the presence of pus in either case.

Hydronephrosis.—This condition is generally unilateral, is caused by the accumulation, within the pelvis, of the renal secretion, and is uncomplicated by inflammation. Its causes may furnish a clue to the diagnosis. They are congenital or acquired obstructions of the ureter, either partial or complete. The existence of congenital obstructions can rarely be ascertained. Among the causes of acquired obstruction are impacted calculi, the pressure of pelvic tumors, especially those of uterine origin, stricture of the urethra, cystic diseases, as cancer and hypertrophy, which obstruct the orifices of the ureters, and cicatricial contractions of the latter. The tumor is fluctuating; sometimes of large size, insensitive, usually smooth, but occasionally nodular and lobulated; constitutional symptoms and local pain are absent. The urine, which is ordinarily normal, may be suddenly augmented in quantity by the removal of the obstruction, the lumbar enlargement simultaneously disappearing. The fluid obtained by aspiration is free from blood and pus, and commonly contains urinary constituents, although these may, in very rare instances, be wanting.

Hydatids of the Kidney.—A tumor, varying in size from that of an orange to that of an adult's head, is found, according to Roberts, in only one-third of these rare cases. The tumor is generally smooth, painless, fluctuating, elastic, and, at first, insensitive; it may, rarely, present the hydatid thrill. When adhesions are formed the tumor excites pain from inflammation and ulceration, and it may rupture into the pelvis, stomach, or intestine, the characteristic fluid being then evacuated through these channels. The disease is unilateral, and especially attacks men. There are no constitutional symptoms, unless suppuration of the sac or secondary adhesive inflammation occur. The urine is normal, unless rupture into the renal pelvis takes place, when the echinococci hooklets are detected, the tumor meantime subsiding. The passage of the hooklets to the bladder may excite renal colic, and their arrival in the viscus often produces vesical tenesmus. Fluid withdrawn by aspiration presents the characteristic appearances noticed in the description of analogous hepatic tumors.

Renal cysts closely resemble hydronephrosis in signs and symptoms, but no cause for obstruction of the ureter is demonstrable. The cysts do not, generally, occasion constitutional symptoms, except in the advanced stages, when they may lead to uræmia. The cysts are painless, smooth, insensitive, and fluctuating; the urine is commonly slightly albuminous or bloody, and of low specific gravity; its quantity is often abnormally large. The fluid obtained by aspiration differs from that withdrawn in hydronephrosis in frequently containing pus and blood, but may possess a distinctly urinous character.

4. Tumors of the Spleen.

These are either temporary or permanent. The former class embraces rapidly-developed and temporary splenic enlargements, due to physiological congestion, inflammation, and acute febrile processes. The latter class includes enlargements from chronic malarial poisoning, leucocythæmia, pseudo-leucocythæmia, obstruction to the portal circulation incident to hepatic, pulmonary, or cardiac diseases, waxy degeneration, cancer, syphilomata, tubercles, hydatids, and splenic ectopia. The splenic enlargement common to all the above-mentioned conditions occasions a feeling of weight in the left hypochondrium, and is revealed by *inspection,* which often shows a more or less marked prominence over the normal site of the organ, and in the neighboring abdominal and thoracic regions. *Palpation* reveals the form of the spleen, which it retains even when greatly enlarged, its consistency, its notched anterior border, its descent during deep inspiration, its mobility on change of posture, unless this be prevented by adhesions, the rounded character of the tumor's lower border, and the possible upward displacement of the heart. *Percussion* accurately defines the exact limits of the organ, which may sometimes reach the iliac fossæ. The various splenic tumors must be distinguished from each other rather by their concomitant conditions than by their individual physical characters.

(*a*) Temporary Enlargements. — *Physiological congestion,* leading to temporary enlargement, occurs habitually after eating, and at the menstrual epoch, but is accompanied by no pain, tenderness, or other abnormal symptoms. *Inflammatory splenic enlargements* may be either local or general. They are due to traumatism, the history of which can easily be obtained, to extension of inflammation from neighboring organs, to hemorrhagic infarctions, or to embolism in pyæmic endocarditis. In the last two cases abscesses, fluctuating and yielding pus on aspiration, may be formed, and will excite the ordinary constitutional symptoms of suppuration; the tumors are usually painful and sensitive; the existence of perisplenitis is shown by the discovery of a friction-sound, occasioned by the respiratory movements of the diaphragm and by the occurrence of lancinating pains. The abscess may rupture into the stomach, bowel, or peritoneum. In the first and second cases pus will be rejected by vomiting or in the evacuations; in the last instance peritonitis rapidly supervenes. If the abscess be small, the above signs and symptoms may be absent, and the diagnosis be impracticable. Perinephritic abscesses may offer insuperable obstacles to a correct differential diagnosis.

The *splenic enlargements dependent upon acute febrile diseases* occur, most frequently, in connection with malarial, typhoid, and puerperal fevers and in pyæmia, but are often observed in the eruptive fevers, in diphtheria, cerebro-spinal fever, pneumonia, erysipelas, and acute miliary tuberculosis. The presence of symptoms characteristic of these diseases, with the usually rapid subsidence of the tumor, after defervescence, will demonstrate the acute nature of the enlargement.

(*b*) Permanent Enlargements.—The chronic splenic enlargement, familiarly known as *ague-cake,* will be distinguished by the history of past or present acute malarial attacks, and by the existence of the malarial cachexia; pigment-particles may be discovered in the blood. In *leucocythæmia* and *pseudo-leucocythæmia,* the lymphatic glands are hypertrophied, as well as the

spleen, and in the former disease the white corpuscles will be present in abnormally large proportions in the blood. Anasarca, fever, and hæmorrhage from mucous surfaces are quite constant advanced symptoms of both conditions. Splenic tumors, dependent upon *portal obstruction*, will be accompanied by the symptoms characteristic of the morbid conditions producing the obstruction; these are mainly mitral and tricuspid valvular lesions, fibroid phthisis, chronic pleurisy with retraction, pulmonary emphysema, obstruction of the inferior vena cava by thoracic tumors, cirrhosis of the liver, pylethrombosis, pylephlebitis, and such hepatic tumors as exert pressure directly on the portal vein. Other symptoms of portal obstruction will facilitate the diagnosis, especially gastro-enteritis, hemorrhoids, ascites, and, in the case of portal congestion from intra-thoracic disease, the symptoms of chronic renal congestion. *The amyloid spleen* is developed in connection with waxy degeneration of the liver, intestines, and kidney, which will present a familiar train of symptoms, and which are etiologically dependent upon chronic suppurative processes or syphilis. *Cancer of the spleen* is rare and always secondary; its existence will be inferred if a tender and painful splenic tumor be developed consecutively to carcinoma of abdominal, pelvic, or thoracic viscera. *Gummata in the spleen* impart no distinctive characters to the splenic tumor, but the presence of syphilomata in other organs or tissues and the history of constitutional infection will facilitate the diagnosis. *Tubercles* are developed in the spleen during general tuberculosis, but offer no pathognomonic signs; their existence may be assumed in the absence of other causes for splenic enlargement and in the presence of symptoms of acute tuberculosis. *Hydatids of the spleen* are generally coincident with their existence in the peritoneum or liver; they may present the hydatid thrill and fluctuation; the discovery of hooklets in the fluid withdrawn from the tumor establishes the diagnosis. *Splenic ectopia* is due to increased size and weight of the organ incident to various morbid conditions. The tumor presents the characteristic splenic contour and smoothness, but is usually tender and accompanied by other symptoms produced by pressure on adjacent organs. The abdominal tumors, most frequently confounded with splenic enlargements, are those of the left lobe of the liver, of the stomach, particularly cancer; of the kidney, the omentum, the pancreas, the ovary, and tumors due to fæcal impaction in the splenic flexure of the colon. For the diagnosis of these enlargements the reader will please see the remarks under their respective titles.

5. Tumors of the Pancreas.

These tumors frequently oppose insurmountable difficulties to the diagnostician on account of their depth, their rarity, and the ambiguity of their symptoms. Those pancreatic diseases producing perceptible tumors are cancer, cystic degeneration, and acute or chronic inflammation. All of these morbid conditions produce immovable epigastric tumors, unaffected by deep inspiration, and occasional symptoms of all are glycosuria and fatty diarrhœa due to interference with the pancreatic digestive functions. All the tumors may occasion grave disturbances by compressing neighboring organs.

Cancer of the pancreas is commonly secondary to gastric, omental, retroperitoneal, or hepatic carcinoma. It is generally of the scirrhous variety, attacks men over forty years of age, by preference, is usually developed, if primary, in the head of the organ, and may involve any adjacent viscus. The tumor, present, according to Bartholow, in one-third of the cases, is transverse and sensitive. The neighboring lymph-glands may be enlarged and cachexia apparent; pain, often radiating into the back, is present and is aggravated by the erect posture; it is frequently paroxysmal and is intensified by deglutition, coughing, or the assumption of the abdominal decubitus, and is relieved when the body is bent forward. Emesis, jaundice, constipation, gastrectasia, ascites, œdema of the lower extremities, and pancreatic cysts may result from pressure on the stomach, ductus communis, duodenum, portal vein, vena cava, and pancreatic duct.

A pancreatic cyst produces a spherical, insensitive, uniform or lobulated epigastric tumor, unattended by pain or symptoms, other than glycosuria and fatty diarrhœa, and commonly referable to obstruction of Wirsung's duct by pancreatic calculi, by the pressure of neighboring neoplasms, or by interstitial inflammation. It may, according to Bristowe, attain the size of an orange.

Chronic interstitial inflammation of the pancreas gives rise to an indurated, painless, and insensitive enlargement in the epigastrium, possibly accompanied by the symptoms already described as common to all pancreatic tumors. *Acute pancreatitis*, which may result from the abuse of mercury or may occur as a complication of puerperal and essential fevers, presents a soft, painful, tender, fluctuating tumor, often attended by emesis and pyrexia. Pancreatic tumors are to be distinguished from cancer of the pylorus, abdominal aneurism, omental tumors, and biliary calculi. Pyloric carcinoma usually presents more marked gastric symptoms, with hæmatemesis and melæna; the pylorus is, however, often involved simultaneously with the pancreas. The characteristics of abdominal aneurisms are stated in the article on that subject. Omental tumors are more superficial and, if tuberculous or cancerous, excite chronic peritonitis. The diagnostic features of biliary calculi will be found in the article devoted to that affection.

6. Tumors of the Intestine.

The intestinal tumors possessing the greatest clinical interest are due either to cancer, fæcal impaction, or to various forms of obstruction. Intestinal sarcomata, myomata, fibromata, adenomata, lipomata, angiomata, papillomata, and cysts also occur, but the first of these can hardly be differentiated from cancer, and the others are ordinarily of such small size as to escape detection.

The diagnosis of *intestinal cancer* must be mainly based upon its situation and its symptoms. It is, generally, inherited and primary, is developed after the fortieth year, most frequently attacks the rectum, sigmoid flexure, and cæcum, but is, sometimes, found in the duodenum and, rarely, in the jejunum or ileum. Pain, intestinal obstruction, the presence of a sensitive tumor, constipation followed by diarrhœa, and cachexia are common to all intestinal carcinomata, wherever situated, although these symptoms are not constant. If the *rectum* be the seat of the new-growth it will be easily discovered and microscopically examined; the pain may radiate into the thighs and testes, the fæces will be ribbon-shaped early in the disease, and later will be mingled with blood, pus, and putrid particles of the cancer. Should the first portion of the *duodenum* be involved there may be emesis, the *ejecta* sometimes presenting the appearance of coffee-grounds, or icterus from occlusion of the common bile-duct. *Diagnosis.*—Intestinal cancer must be differentiated from aneurisms, fæcal tumors, carcinomata, and other tumors of neighboring abdominal organs, from floating kidney, enteritis, and intestinal ulceration, and from all other causes of intestinal obstruction. Enteritis and ulceration can be excluded by the absence of tumor, constipation, and cachexia in those diseases. The diagnosis of the other morbid conditions simulating cancer is presented in connection with their general description.

Fæcal Tumors.—These are situated in the colon, and most frequently at the sigmoid, splenic, or hepatic flexures, and in the cæcum. The tumor will be found in the course of the bowel, its long diameter corresponding to that of the intestine; it may be nodular, but is not sensitive, and can be indented by the finger; owing to its inelasticity the fæcal mass retains the digital indentation. The tumor can often be displaced in the axis of the intestine; diarrhœa may be present from irritation, although constipation is the rule. The absence of cachexia, constitutional symptoms, and pain facilitate the exclusion of cancer and of other intestinal obstructions.

Free purgation usually completely removes the tumor, which often spontaneously changes its position.

INTESTINAL OBSTRUCTION.—The classification of intestinal obstructions here adopted is derived from the lectures of Dr. H. B. Sands. It embraces: 1. Errors of position, as intussusception and volvulus. 2. Compression from bands, diverticula, accidental rings, internal hernias, benign or malignant tumors. 3. Obturation from foreign bodies, polypi, gall-stones, enteroliths, or fæcal masses. 4. Strictures of the bowel, either fibrous or malignant. The symptoms of *invagination* are somewhat different from those of other obstructions. They ordinarily supervene rapidly, the patients being, usually, children who have suffered for some days from diarrhœa. The symptoms are, chiefly, severe localized pain; the development of a tender, rather soft abdominal tumor, which yields a dull note on percussion, may change its form or position, and is most frequently found in the right iliac fossa; emesis, sometimes stercoraceous and diarrhœal, or sanguinolent evacuations which may contain gangrenous shreds or masses. The leading *symptoms of the other varieties of obstruction* are obstipation; vomiting, which appears early, is bilious at first and may remain so if the obstruction be high up in the small intestine, but which comes late and becomes stercoraceous if the small bowel be occluded low down, or the colon at any part of its course; the formation of a sensitive, painful tumor, dull on percussion, if the obstruction be not too high in the small intestine; increasing tympanites above the tumor, singultus, lowered temperature, and finally collapse. The *diagnosis* relates both to the nature and the situation of the obstruction. The existence of invagination may be inferred if obstruction suddenly occur in a child previously affected with diarrhœa, and be accompanied by bloody stools; a rectal examination may confirm the diagnosis. *Volvulus* is sometimes induced by violent muscular exertions, as in jumping or lifting. If the history points to pre-existing peritonitis, or to other abdominal tumors, *obstruction from compression* is probable. Should there be a history of biliary colic, obstruction by a gall-stone or by fæcal masses developed around a calculus is assumed. The pre-existence of ulcers points to strictures of the bowel. The *situation* may be determined by exact localization of the original tumor, but this often fails. In obstruction of the duodenum or jejunum the urine is scanty, the abdomen undistended, and the ejecta bilious in character; if the cæcum be the seat of the occlusion the large intestine will be empty, but the latter will be distended throughout if the rectum be obstructed; if a rectal tube can be made to penetrate a foot or more, the rectum and sigmoid are free; if the colon can be distended throughout by injected air or water, it is, of course, unobstructed. Simon's method of manual intrarectal examination may furnish important information. *Differential Diagnosis.*—The chief conditions with which obstruction may be confounded are peritonitis, acute gastritis, hepatic and renal colic, enteritis, external hernia, simple enteralgia, and gastralgia. *Peritonitis* is characterized by great tenderness, high temperature, and incompressible pulse, a peculiar decubitus, and facies. *Acute gastritis* is marked by elevation of temperature, and by great tenderness and heat of the epigastrium; there is no obstinate constipation, but often diarrhœa; the ejecta are not stercoraceous. In *hepatic colic* there is no tympanites, fæcal vomiting, or obstipation; the pain begins suddenly, radiates from the right hypochondrium to the right shoulder, or into the back, and ceases abruptly; there may be jaundice and colorless stools; bile is found in the urine and the calculus is perhaps detected in the evacuations. In *renal colic* there is no fever, tympanites, fæcal emesis, or constipation; the pain, which begins and ceases abruptly, radiates into the penis and thighs; the urine is often bloody, and may contain uric acid crystals or the offending calculus; the testicle is retracted. *Enteritis* is accompanied by diffused abdominal pain and tenderness, by diarrhœa and an elevated temperature, but not by emesis or tympanites. *Inguinal and femoral hernias* are excluded by a thorough physical examination. *Enteralgia and gastralgia* are devoid of the leading symptoms of obstruction, while the pain of these neuralgic affections is paroxysmal and may be relieved by pressure.

7. TUMORS OF THE OMENTUM.

The omental tumors most deserving of attention are cancer, tubercle, and hydatids. Fibromata, hæmatomata, myxomata, dermoid and simple cysts are also developed from the omentum, but are so rare as not to claim consideration in this place.

Omental cancer, a rare disease, as compared with tubercle, is usually secondary to cancerous degeneration of other abdominal organs or of the sexual apparatus, but may be primary, particularly if of the colloid variety. Its *signs* are those of tumors, either nodular or diffuse, which sometimes attain large dimensions, are bilateral, superficial, tender, movable, unless bound down by peritoneal adhesions, and often accompanied by paroxysmal pain and peritoneal friction-sounds.

Omental tubercles, although occasionally primary, generally merely constitute one local manifestation of general tuberculosis, the point of departure for which may have been the lungs or the genito-urinary organs. The tuberculous nodules are too minute to be certainly disclosed by physical exploration. Cancer, tubercle, and hydatids excite chronic peritonitis, which is often insidious in development, and latent as regards symptoms; cancer and tubercle present, in addition, their familiar trains of constitutional symptoms, and, generally, evidences of the primary disease. In tuberculosis there is more frequently pleuritis, diarrhœa, fever, emesis, and tympanites than in cancer, and the average age of the patients is less. The fluid withdrawn from the peritoneal cavity in cancer is said, by Foulis and Thornton, to contain characteristic groups of large, budding cells.

Hydatids of the omentum may present the characteristic fremitus, and yield fluid containing echinococci hooklets; they excite less constitutional disturbance than cancer or tubercle, but may exceed either in size. Ascites is often mistaken for chronic peritonitis, secondary to omental tumors; it is, however, not accompanied by fever, pain, or abdominal tenderness. Ascites is, moreover, caused by cirrhosis of the liver, or by obstruction to the hepatic circulation from intrathoracic diseases, which also occasion splenic enlargement, gastro-enteritis, and distention of the superficial abdominal veins.

8. TUMORS OF THE BLADDER.

New-growths in the bladder are cancerous, tuberculous, villous, or fibrous in nature, but do not occasion sufficient enlargements to justify their inclusion among abdominal tumors. *Vesical cancer* is generally secondary to other pelvic carcinomata, and causes cystitis, enlargement of lumbar glands, and sudden, abundant hemorrhages. *Cystic tubercles* are secondary to tuberculous deposits in other genito-urinary organs, or occur in general tuberculosis. *Villous tumors* produce long-continued parenchymatous hemorrhages. *Fibroids* occasion cystitis and dysuria.

A distended bladder occupies, first, the hypogastrium, and gradually invades the adjoining regions. The tumor is oval, central, flat on percussion, smooth, painless, and insensitive, until an extreme degree of distention is reached, and sometimes fluctuating. Catheterism establishes the differential diagnosis between vesical distention and ascites or uterine tumors. Distention should always be sought for in delirious or comatose patients, and will often be found in cases of incontinence following atony. In these cases the history of frequent urination sometimes causes the physician to overlook the necessity for physical exploration.

9. UTERINE TUMORS.

The principal causes of uterine enlargements are pregnancy, hydatidiform mole, retained dead fœtus, retained

menstrual or serous fluid, fibromata, fibro-cystomata, carcinomata, sarcomata, and physometra. If the uterine abdominal tumor be of small size it will occupy the hypogastrium, unless adhesions from antecedent peri-uterine inflammation or other abdominal enlargements exert such traction or pressure upon it as to displace it into one of the inguinal regions.

If *normal pregnancy* exist it will be revealed, after the fourth month, by the fœtal heart-sounds, the uterine souffle, *ballottement*, and the fœtal movements, together with the familiar mammary and cervical changes; the tumor is firm, non-fluctuating, and inelastic. If a *dead fœtus be retained in utero*, the history will be that of normal pregnancy up to a certain time, after which no evidence of fœtal vitality or of progressive uterine enlargement can be obtained. Having undergone either maceration or mummification, the fœtus may be expelled before the expiration of the normal period of utero-gestation, or, having been transformed into a *lithopœdion*, may be indefinitely retained. The *hydatidiform mole*, when of large size, is distinguished by the occurrence of uterine contractions, resulting in the expulsion of a muco-sanguinolent fluid containing the cysts peculiar to this disease, possibly by the presence of slight fluctuation, by unusually rapid enlargement of the uterus, by the failure of *ballottement*, and by the absence of fœtal heart-sounds. If the tumor be due to *retained menstrual fluid*, the signs of pregnancy will be absent, the discharge at each menstrual epoch will be insignificant or absent, intense pain will recur at each period, and physical examination will disclose obstruction of the genital canal. The history will, also, often point to some antecedent inflammatory disease of such a nature as to have occasioned occlusion of the genital passage.

The accumulation of a *serous discharge from the endometrium*, in old women, will present the above signs and symptoms without periodicity or severe pain.

The connection of *uterine neoplasmata*, which have not involved neighboring viscera, with that organ is shown by the displacement of the tumor when the uterus is moved either by the palpating finger or the uterine sound, by the elongation of the uterine cavity, ascertained with the probe, and by the results of abdominal palpation, vaginal exploration, Simon's intra-rectal method, or by a combination of these methods of examination. The symptoms of pregnancy are absent. *Uterine fibroids* attack the body or fundus of the organ, by preference, and cause irregular, unsymmetrical enlargement; their consistency is firm; they are usually developed between the thirtieth and forty-fifth year. Negresses are especially predisposed. The chief symptoms are metrorrhagia or menorrhagia, pain from pressure on the pelvic nerves, uterine tenesmus, dysmenorrhœa, leucorrhœa, and hydrorrhœa. *Fibrocystomata of the uterus* may present obscure fluctuation and yield fluid on aspiration, which does not possess the characters of ovarian fluid; their growth is more rapid than that of fibromata, and their size usually greater. *Uterine carcinomata* attack aged multiparæ possessed of an hereditary predisposition; they generally affect the cervix, but may invade the body and fundus, when they become accessible to examination through the abdominal walls; they are hard and nodular until ulceration occurs, after which an irregular and bleeding ulcer remains; the microscope decides the character of the neoplasm. Menorrhagia, metrorrhagia, fetid discharge, and cachexia are the chief rational symptoms. *Sarcomata* always develop in the uterine body, are generally soft and friable, though sometimes hard; the cervix is dilated, and the uterine cavity enlarged; there are present menorrhagia, metrorrhagia, uterine tenesmus, and an offensive discharge; the microscope establishes the diagnosis. *Physometra or Tympanites Uteri.*—This rare condition, dependent on the presence of air or gas in the uterine cavity, is shown by the existence of tympanitic resonance over the entire organ. Tympanites uteri occurs during labor, as the result of the entrance of air through the ruptured membranes, and is either due to the air alone or to the gases which are the product of putrefactive processes excited by the presence of air, heat, and moisture *in utero*. The pains grow feeble or cease in physometra, there is an offensive discharge from the uterus, and septic symptoms ensue. Ovarian tumors, spurious pregnancy, ascites, cysts of the broad ligaments, and salpingitis may be mistaken for uterine tumors.

10. Ovarian Tumors.

These enlargements occur with greater frequency than all other abdominal tumors. They appear first in the iliac fossæ, and gradually extend to the adjoining regions. On *inspection* they present, early in the disease, an irregular, unilateral, more or less globular projection. In the later stages this prominence may occupy all the abdominal regions, being especially marked in the middle line. The tumors may, according to their structure, be hard and unyielding, or soft and fluctuating. They are movable, unless adhesions have formed between them and neighboring viscera, and may be either sensitive or insensitive, painful or the reverse. Flatness *on percussion* exists over the tumor, and does not change place with alterations in the patient's position. Tympanitic intestinal resonance is found above the tumor and, often, on either side of it. The uterus is generally movable, of normal size, and displaced backward or laterally. It is often found behind the ovary, as is the large intestine. An aortic impulse may be imparted to the enlarged ovary.

Ovarian neoplàsmata are, according to the classification of Thomas, either solid or cystic. The leading members of the former group are cancers and fibroids, those of the latter are cysto-fibromas, cysto-carcinomas, dermoid cysts, ovarian cysts, and cystomata. Acute ovaritis also leads to enlargement of the organ.

Solid Tumors.—*Cancer.*—A cancerous ovarian tumor is primary or secondary, painful, usually sensitive, and of either firm or soft consistency. It develops rapidly in aged women, and is accompanied by marked asthenia, cachexia, ascites, œdema of the feet, and secondary glandular tumors. *Fibromata of the ovary* are rare, and usually of small size. They are firm, unyielding, insensitive, painless, movable, and of slow growth. *Acute ovaritis* produces enlargement of the exquisitely tender organ, vaginal sensitiveness near the site of the ovary, with vesical tenesmus, febrile movement, and sympathetic emesis.

Cystic Tumors.—*Cysto-fibromata* are of large size, fluctuate, and yield, on aspiration, a serous, sero-sanguinolent, purulent, or colloid material. *Cysto-carcinomata* are characterized by their very rapid development, their involvement of neighboring organs and consequent immobility, their frequently nodular character, their tenderness, their painful nature, and their constitutional symptoms; they are rarer than cysto-fibromata. *Dermoid cysts* are commonly spherical and indurated, single, although occasionally multiple, painless and movable; they vary in size from that of a hen's egg to that of an adult head; they may suppurate, and may rupture into the peritoneal cavity. *Ovarian cysts* present the physical characters described in the introductory remarks on ovarian enlargements, the most striking being fluctuation. The chemical analysis and microscopical examination of the fluid withdrawn are of great diagnostic value; the fluid is not generally spontaneously coagulable; it is usually viscid, sometimes serous, has an average specific gravity of 1.018 or 1.020, and contains albumen and paralbumen; it may contain cholesterine, cylindrical epithelial cells, Drysdale's ovarian corpuscles, the inflammatory cells of Glüge, and blood-corpuscles. The age at which ovarian cysts commonly develop is from twenty to forty years. The leading symptoms are dysuria and dysmenorrhœa, pelvic pain, constipation, and ascites. For some time the general health remains tolerable, but hectic fever, emesis, diarrhœa, œdema, and asthenia finally develop.

Differential Diagnosis.—The abdominal enlargements most likely to be mistaken for ovarian tumors are those of the uterus, bladder, omentum, intestine, broad liga-

ments, and Fallopian tubes. Tumors of the kidneys, stomach, liver, and spleen, must also be differentiated, besides ascites, tympanites, chronic peritonitis, pelvic abscess, cellulitis and hæmatocele, aortic aneurisms, enlargements of the retro-peritoneal glands, osteomata, and enchondromata of the pelvic walls.

Enchondromata and osteomata of the pelvic bones are hard, immovable, non-fluctuating, and contain no fluid; the other morbid conditions mentioned are described, at the proper place in this article, or in those treating of the subjects in question.

11. Miscellaneous Tumors.

Extra-uterine Pregnancy.—The diagnosis of this condition is based, according to Lusk, upon the existence of the signs of pregnancy, the exclusion of an ovum in the uterine cavity, and the presence of a tumor outside the womb. The signs of pregnancy need not be repeated. The absence of an ovum from the uterus is shown by the cautious use of the uterine sound or by the introduction of the finger, after cervical dilatation. The tumor may sometimes be felt before the fourth month by vaginal touch, and, occasionally, after that time, by abdominal palpation. The heart-sounds may then be heard. Dr. Lusk suggests that friction of the abdomen, over the tumor, may aid in the diagnosis, as the uterus will alone contract under this stimulation.

Tubal Dropsy or Hydrosalpinx.—This condition, due to the occlusion of the Fallopian tube, usually from preceding peritonitis or cellulitis and the accumulation of a serous fluid in the tube, leads to the development of a tumor, generally small, but sometimes attaining the dimensions of a child's head. The enlargement is in so close proximity to the ovary that it can be diagnosticated from ovarian cyst only by analysis of the fluid withdrawn.

Cysts of the Broad Ligaments.—These cysts yield a superficial fluctuation and closely simulate ovarian cysts, uterine fibro-cysts, and hydrosalpinx. They are unilocular and, hence, not irregular or nodular. Their differential diagnosis rests on an examination of their fluid contents, which are clear and albuminous. These cysts are generally cured by tapping; they grow slowly and do not interfere with the general health.

Pelvic Hæmatocele.—The tumor designated by this name is usually first developed behind the uterus and vagina, in the cul-de-sac of Douglas, and may extend thence only to the pelvic brim or even as high as the umbilicus. It is at first smooth and fluctuating, later it is nodular and hard; the vagina and rectum are more or less obstructed and the uterus is displaced by the tumor; the enlargement is rapid and is accompanied by shock, metrorrhagia, uterine tenesmus, tympanites, and pelvic pain.

Pelvic Cellulitis.—In the beginning of this affection the only physical sign is great tenderness on one side of the uterus. After effusion has occurred a tumor will be found, and should suppuration ensue, fluctuation will be detected and the uterus will be partially fixed. Metrorrhagia, dysuria, and fever are the chief early rational symptoms. If suppuration take place hectic fever is developed.

Abscesses.—The principal abdominal abscesses are preperitoneal, iliac, lumbar, peritoneal, and parietal. *Abscess in the preperitoneal space,* or the space of Ricius, between the umbilicus and the apex of the bladder, leads to the formation of a tender, painful, deep-seated tumor of the hypogastrium, which occasionally fluctuates, yields pus on aspiration, and excites constitutional symptoms of the hectic type. These abscesses may be traumatic, secondary to bladder or pelvic diseases, or, rarely, idiopathic. *Iliac Abscess.*—Abscess in the iliac fossa may be traumatic, but is generally secondary to perityphlitis, pelvic cellulitis or peritonitis, psoitis, caries or necrosis of the pelvic bones, or to pelvic abscess of whatever origin; lumbar abscesses may also point in this region, and idiopathic abscesses occasionally develop here. Should the abscess be the result of perityphlitis, palpation reveals the deep-seated character of the tumor, and percussion yields an obscure tympanitic resonance. Well-marked tympanites is indicative of rupture of the intestine and the escape of gas into the cellular tissue. In perityphlitic abscess there will be pain in the thigh, inability to flex the latter, emesis, diarrhœa, and perhaps œdema of the lower extremities, with the characteristic constitutional symptoms of suppuration; the aspirator will often obtain pus, which is stercoraceous in odor and actually contains fæcal matter if perforation of the cæcum have given rise to the abscess. Abscesses not due to cæcal disease yield no symptoms relative to the digestive tract and excite comparatively little pain or fever. Small size of the iliac tumor and marked inability on the patient's part to flex the thigh, indicate that the abscess is beneath the iliac fascia, and, therefore, probably not perityphlitic in nature. If the abscess be secondary to pelvic suppuration, the characteristic symptoms of the latter will precede the appearance of the abdominal tumor; if the iliac abscess rupture into the intestine, pus is evacuated with the alvine dejecta; if rupture into the peritoneum take place shock and peritonitis rapidly supervene. *Lumbar Abscess.*—This is secondary to vertebral caries, to suppurative pyelitis, pyelonephritis, renal tubercles, cysts, parasites, and calculi, to typhlitis and perityphlitis by extension from the iliac fossa, to pelvic cellulitis, and to pyæmia, typhus, typhoid, variola, cold, and traumatism. If it result from lumbar vertebral caries the pus, being prevented from infiltrating the connective tissue of the lumbar region by the tense sheath of the psoas muscle, follows the course of the latter, commonly making its appearance in the thigh, below Poupart's ligament, or even at the knee or ankle. In rare instances the psoas abscess may point in the lumbar, the iliac, or in the other abdominal regions. Psoas abscess is especially characterized by pain, tenderness, weakness and stiffness in the spine, pain on flexion of the thigh, and inability to assume or to maintain the erect posture. Lumbar abscesses, other than those due to vertebral disease, generally present a painful, sensitive, lumbar prominence, yielding or fluctuating, and unaffected by the respiratory movements. The rational symptoms of suppuration are present and aspiration yields pus, which, if the abscess emanate from renal disease with perforation of the kidney, will be mingled with urinary constituents. These abscesses may point in various directions and occasion the most diverse symptoms by rupturing into the pleura, peritoneum, pelvis, intestine, renal pelvis, etc. They most frequently open, however, in the lumbar region. *Peritoneal abscesses* are preceded by local or general peritonitis, present obscure fluctuation, and excite hectic fever. They are not affected by the respiratory movements, and yield pus on aspiration. *Abscess of the abdominal wall* is usually traumatic and occasions a superficial, rapidly growing tumor, at first hard, hot, red, painful, and tender, then soft or fluctuating. It is generally connected with the rectus muscle and is located near the umbilicus; coughing and movement cause considerable pain; aspiration, after fluctuation, reveals pus, which may contain degenerated and disintegrated muscular fibres; hectic fever is present. These abscesses may be mistaken for peritoneal abscesses which must be excluded by the absence of sufficient causes or symptoms of intra-abdominal suppuration. The differential diagnosis may, sometimes, be made by causing the patient to forcibly perform the expiratory act, when, the recti having become tense, a superficial tumor will be made more prominent but a deeper one obscured.

Ascites.—This common symptom of various diseases produces general abdominal enlargement, which is especially noticeable, on *inspection,* at the most dependent parts of the abdomen. The abdominal respiratory movements are limited or suspended, and the superficial abdominal veins often greatly distended. Fluctuation is obtained by *palpation,* and *percussion* yields flatness at the lowest portion of the abdomen, irrespective of the patient's position, unless peritoneal adhesions be present, with tympanitic resonance in the highest regions. On

aspiration a yellowish, serous, albuminous, fibrinogenous, spontaneously coagulable fluid, possessing a specific gravity ranging between 1.006 and 1.018, is withdrawn. This fluid may contain chyle. The chief causes of ascites are obstructions to the portal or hepatic circulation from hepatic or intrathoracic disease, and hydræmia incident to various cachexiæ. Ascites may be mistaken for tympanites, ovarian, renal, hepatic, and splenic cysts, for pregnancy, chronic peritonitis, distended bladder, gastrectasia, and cysts of the Fallopian tube. All of these diseases are elsewhere described.

TYMPANITES causes a general abdominal enlargement, over every part of which tympanitic resonance is found. The causes of tympanites are the excessive accumulation of gas in the intestine, or the introduction of air from without. It is incident to indigestion, hysteria, enteritis, and peritonitis.

TUMORS FROM CONTRACTION OF ABDOMINAL MUSCLES.—These tumors are most frequently occasioned by contraction of the rectus abdominis, which causes a prominence yielding a dull percussion-note. This enlargement, if combined with tympanites, constitutes the so-called "phantom tumor," observed, generally, in women, and often mistaken for a serious intra-abdominal swelling. Its true nature may be established by the employment of anæsthetics.

TABES MESENTERICA.—This disease produces abdominal enlargements, which are sensitive and nodular, at first, but which fluctuate at a later stage of the affection. The disease occurs chiefly in so-called scrofulous children, who are greatly emaciated, and who suffer from indigestion, diarrhœa, and fever. The cause of the tumors is tuberculous degeneration of the mesenteric glands. The existence of tuberculosis of other organs affords aid in the establishment of a diagnosis.

TUMORS OF THE RETROPERITONEAL GLANDS are generally cancerous. They may be located in the lumbar or iliac regions. Sometimes they are discovered in the median line, posteriorly, between the last rib and the iliac crest, and occasionally anteriorly, near the *linea alba.* They may involve the diaphragm or the pelvic lymphatic glands, by extension, and may occasion œdema of the lower extremities by compressing the *vena cava.* The characteristic cancerous cachexia is sooner or later developed.

William H. Flint.

ABERYSTWITH. A much-frequented seaside resort on the coast of Wales. The town of Aberystwith lies on the shore of Cardigan Bay; its population, in 1871, was 6,898; it possesses a fine beach; has excellent hotel accommodations; and, situated as it is in the midst of some of the most attractive scenery of Wales, the excursions into the surrounding country are very enjoyable. Concerning the climate of Aberystwith, the writer is unable to present accurate data for the place itself, but the subjoined table, copied from Hann's *Handbuch der Klimatologie,* may serve to give some idea of its temperature during the colder months of the year. Llandudno lying some 75 miles north of Aberystwith, and Barnstaple lying about 125 miles to the south, both of which places have a similar exposure to that of Aberystwith, it is fair to assume that the temperature of the latter place differs but little from that of either of the above-mentioned towns, whose average temperature is given by Dr. Hann. It would therefore appear that the winter temperature of Aberystwith must be very little colder that that of Ventnor in the Isle of Wight, the figures for which latter resort are also quoted from Hann's table for purposes of comparison.

Name of Place.	N. Lat.	Nov.	Dec.	Jan.	Feb.	Mar.
Llandudno	53° 21′	44.96°	42.44°	41.72°	42.44°	43.70°
Barnstaple	51° 5′	45.50°	42.62°	42.26°	43.34°	44.96°
Ventnor	50° 35′	46.22°	43.16°	41.72°	42.62°	44.24°
Aberystwith	52° 25′					

H. R.

ABORTION. While most Continental writers apply the term abortion to all cases in which the product of conception is expelled from the uterus at any time preceding the period at which the fœtus becomes viable, that is to say, before the seventh calendar month of gestation in the human subject, many American and English writers make a distinction between abortion and miscarriage, restricting the former term to the expulsion of the ovum prior to the fifth month, and applying the latter to such expulsion between the fourth and the seventh months. This distinction, although more or less arbitrary, has some practical justification, inasmuch as abortion, thus defined, differs notably in several particulars from the process of parturition at term—a difference that becomes trifling in the case of miscarriage. It is well for the practitioner to use the word miscarriage when talking to patients, for women seem to have an aversion to the term abortion. Certain qualifying words are occasionally added, such as "ovular," "embryonal," and "fœtal," but they are of little real significance.

Causes.—These attach either to mechanical injuries to the ovum or its uterine attachment, to morbid conditions of the ovum, or to diseases of the maternal organism. Under the first head must be included not only direct traumatism, but also hæmorrhages between the fœtal and the maternal layers of the placenta, whether due to violence, such as falls, blows, and the like, or to a diseased state in either the mother or the ovum; the latter, of course, falling also under one of the remaining heads. Strictly speaking, indeed, the immediate cause of almost every abortion is some abnormal state of the ovum resulting in the death of the embryo, but this in turn may be due to some defect in the maternal organism, or, for that matter, to disease in the father, as exemplified by the frequency with which abortion takes place as the result of syphilitic contamination of one or the other of the parents. Habitual abortion, it is well known, raises the presumption of syphilis. As regards pathological conditions of the ovum, it is generally to disease of the placenta, or a crippling of its respiratory and nutritive functions by effused blood, that the death of the embryo is to be traced, although cases are not wanting in which the circulation in the umbilical vessels has been so interfered with as to produce the same result.

In so far as the mother's system is at fault, much stress was laid by the older writers on the "habit of abortion." It was taught that when several successive pregnancies in the same subject had ended in abortion, no matter what the cause, a habit was thereby established by virtue of which there was a tendency for subsequent pregnancies to end in the same way, and at about the same period, even if the original causes were no longer operative. There may be some truth in this doctrine, but it certainly has not now the hold upon medical opinion that it had formerly. The exanthematous fevers, it is well known, and particularly small-pox, are prone to give rise to abortion, either by infecting the embryo, or by the tendency to hæmorrhages, uterine among the others, to which they give rise. Apart from these acute diseases, it is possible that various depraved conditions of health on the part of the mother may occasion abortion, but on this score our precise knowledge is meagre. There are certain medicinal substances that, when taken into the mother's system, may induce uterine contraction, and thus bring about the premature expulsion of the ovum, such as spurred grain (generally ergot of rye) and cotton-root. Excessive purgation also may lead to the same result. Surgical operations done on pregnant women have been supposed to involve grave risk of abortion, but evidence has been accumulating of late years to show that this danger has been overrated. A striking example is seen in the frequency with which even so serious an operation as ovariotomy is performed during pregnancy without interrupting the process of gestation.

Various morbid conditions of the uterus and its surroundings, however, are justly credited with producing a tendency to abortion, but, with regard to one of them,

it seems to me that more has been assumed than the facts warrant. I refer to laceration of the cervix, whereby a lack of retentive power is said to be set up. It cannot be denied that lacerations are often accompanied by conditions unfavorable to the due continuance of gestation, or that they tend to keep up such conditions, even if not directly chargeable with their production, but this is quite a different matter from admitting a loss of mechanical retentive power in the cervix as a cause of abortion, for it should be borne in mind that the ovum maintains its position in the uterus by the implantation of its chorionic villi in the uterine mucous membrane, and not in any sense by resting on a support beneath, as on a shelf.

Abortion induced for therapeutical purposes will be found treated of under the head of Labor, Premature, Induction of.

Frequency.—Although abortion does not figure prominently in the statistical lists of public institutions, since it is only under unusual circumstances that women betake themselves to a hospital during the process, the general experience of family practitioners shows that its occurrence is common. Add to the cases they are called upon to treat those which are brought to their knowledge long after they have taken place, while questioning patients as to their past history, and allowing for those that are concealed, as well as for those as to which there is an honest feeling of doubt (since it is unquestionable that many abortions occur during the very early weeks of gestation, before the existence of that condition is suspected, and are mistaken for a mere unusually copious and painful menstruation), and we find ourselves obliged to admit that abortion is by no means of uncommon occurrence. As to the period of gestation at which it oftenest takes place, the experience of most writers is to the effect that it is on the completion of two and a half or three months of gestation, leaving out of account the very early abortions before alluded to, since they are involved in so much uncertainty that it is impracticable to estimate their frequency with any approach to precision.

Symptoms and Diagnosis.—Sometimes the ovum is cast off rapidly, with scarcely a symptom beyond a sharp onset of abdominal pain, and a few gushes of blood. In such cases, either the diagnosis is established very promptly, or else it is never made with certainty; but it never rests on symptoms. These cases, however, are exceptional. Usually a considerable period is occupied by certain symptoms pointing to a disturbance going on within the pelvis, notably, uterine hæmorrhage and pains like those of labor. When these two phenomena are found to coexist in a marked degree in a woman supposed to be pregnant, the inference that an abortion is impending presents itself at once, and most commonly it will be justified by the event. But such is not always the case. Uterine hæmorrhage, or at least hæmorrhage from the cervix, is not very uncommon in pregnant women who go to full term, depending generally on antecedent uterine disease. Let one of these hæmorrhages coincide with an attack of colic, or of lumbago even, and the symptoms that ordinarily usher in an abortion may be very closely counterfeited. It may even happen that what, in a certain sense, may be called a product of conception, may be expelled from the uterus, and yet no abortion takes place. Reference is here had to the decidua that is commonly cast off from the uterus in cases of extra-uterine pregnancy, a condition that is most frequently accompanied, too, by hæmorrhage.

Still, with every allowance for these exceptional occurrences, the fact remains that paroxysmal uterine pain, accompanied by a flow of blood from the vagina, almost invariably, when met with in a pregnant woman, presages the premature expulsion of the ovum. This suspicion once aroused in the practitioner's mind, the first thing to be settled is the question of the existence of pregnancy. The diagnosis of pregnancy will be found treated of elsewhere in this work, and, therefore, it will not now be dwelt upon. Nor, for practical purposes, is it necessary to give much more consideration to the diagnosis of threatened abortion. The practical rule should be, in all cases in which the two symptoms, uterine pain and uterine hæmorrhage, are marked in a pregnant woman, to treat her as if an abortion were impending. There are, indeed, certain cases of uterine disease that may simulate abortion very closely—notably cases of submucous uterine tumors so situated and so attached as to cause expulsive pains by the impediment they may offer to the escape of the flow of blood to which their presence gives rise. In such instances, however, we shall usually be able to get the history of past occurrences of the sort —a history to be contrasted with the sharp picture of suspended menstruation followed by a profuse and painful flow in a woman previously free from such troubles. A more difficult problem is presented in cases where an abortion is really in process, but has been arrested in its course. Perhaps the simplest form of this condition is the so-called "cervical pregnancy" of certain German writers, in which the ovum is detached from its connection with the uterine wall, and is forced down into the cervical canal, where it is retained in consequence of a failure of the os externum to dilate, or simply by reason of a suspension of the uterine contractions. These cases commonly offer no special diagnostic difficulty, and, the retention being but transitory, any doubt is speedily cleared up. A more common irregularity is the rupture of the fœtal membranes and the escape of the fœtus, either unperceived or unacknowledged, before medical aid is summoned, the placenta still being retained. Under such circumstances, it happens not infrequently that the patient resumes her ordinary course of life, seeking treatment, if at all, only on account of a uterine discharge, which may not even be bloody. In such instances the uterus will be found enlarged and especially elongated, freely movable, free from tenderness, and with nothing to account for its enlargement and its peculiar shape save the supposition of an incomplete abortion, and usually the question can speedily be settled by giving ergot—a practice quite safe under such circumstances. It is scarcely necessary to add that, in all cases of suspected abortion, everything expelled from the vagina should be saved for examination. In the absence of the embryo, the recognition of chorionic villi will be decisive. These will often be found on the inner side of the bag-like structure expelled, the membranes having been turned inside out in the process of expulsion. In very early abortions the ovum is usually cast off entire.

Prognosis and Sequelæ.—If we disregard the fœtus, which is necessarily sacrificed, the prognosis for the mother is always a matter of some doubt, but generally, provided the case is well managed, favorable. The immediate danger is from hæmorrhage, which ceases on the complete evacuation of the uterus; next, and much more to be feared, is the risk of septic fever from the absorption of decomposing portions of the ovum retained in the uterus; these perils passed, inflammatory complications, subinvolution, and the like are still to be feared. But very few women die from the direct effects of hæmorrhage occasioned by abortion, but many are exsanguinated to a degree that materially deteriorates their health; more often they succumb to septic absorption. The acute inflammatory sequelæ may be either peritonitis, cellulitis, oöphoritis, or any one of the various forms of metritis. Aside from the part played by mild septic contamination, these affections are largely dependent on the cause of the abortion, being uncommon in cases not occasioned by instrumental interference. On the whole, it may be said that the great majority of women escape a fatal result. At the same time, abortion is one of the most fertile causes of chronic pelvic disease; usually, however, these consequences may be avoided by careful treatment.

Treatment.—This resolves itself into the prevention of abortion, the management of the process, and the after-treatment. If we admit the "habit" of abortion, we must usually look for its solution in some degeneration of the placenta, whereby it becomes unfitted to carry on the processes of respiration and nutrition for the embryo. This occurrence may be due to syphilis; in that case

mercurial treatment affords the main chance of success; the corrosive chloride of mercury in doses of from one-thirty-second to one-twenty-fourth of a grain, three times a day, will commonly be found to afford all the advantage that is to be gained in this direction. In the absence of syphilitic infection, some obstetricians believe that an error of hæmatosis is often at the bottom of repeated abortions, and on this theory the administration of chlorate of potassium has been recommended. I am not aware, either that the theory is well founded or that the remedy is of any value; still, with proper precaution, there can be no objection to its use—that precaution being to guard against the injurious effects of the drug upon the kidneys; and, therefore, to avoid large doses, and to abstain from them particularly in cases where the pregnancy is somewhat advanced, since the latter months of gestation are apt to be fraught with more or less interference with the renal function. As for the use of so-called uterine sedatives, it is not to be thought of until the process of abortion is actually threatened. Of course, such patients as are now referred to should be instructed to refrain from all the excesses and irregularities that have been mentioned as among the exciting causes of abortion.

Suppose, however, that symptoms are present showing that an abortion is imminent. In many instances the process may be prevented, and the expectation of success should not be abandoned until there is physical evidence that the expulsion of the ovum is going on. No amount of hæmorrhage and no amount of pain, within ordinary bounds, should be taken in themselves as rendering attempts at prevention absolutely hopeless. Perfect rest is to be enjoined, but the low diet and cooling drinks of bygone times are not to be depended upon in the slightest; the moderate use of opium and the application of heat to the spinal column, at the junction of the dorsal with the lumbar portions, are the most trustworthy measures. Theoretically, we may admit that ergot may sometimes be useful, by checking a hæmorrhage that might detach the placenta, but, practically, there is such danger of its inducing uterine contraction that it must be regarded as at best but a doubtful remedy. The use of viburnum prunifolium has of late years been recommended as a uterine sedative, and there is respectable testimony in its behalf. It should be given in doses of half a teaspoonful of the fluid extract every three hours. To mitigate its disgusting taste, it may be combined with an equal amount of tincture of cinnamon.

When it has once become evident that abortion must take place, the safe conduct of the case calls for close supervision; but, even then, discretion is usually more to be advised than activity. Ordinarily, manual interference is quite unnecessary, beyond what may be needed to keep the physician informed of the progress made, and to check hæmorrhage. The utmost pains should be taken to maintain the integrity of the ovum as long as possible, for when it is expelled entire there is commonly an end to all anxiety. Herein, in great measure, lies the safety of accidental abortions as compared with those induced by criminal practices, in which the fœtal envelopes are almost always punctured, with the result of allowing the embryo to be cast off early in the process of abortion, while the secundines remain behind, a shapeless mass, upon which the uterus has to act at a great mechanical disadvantage. So long as rupture of the membranes can be prevented, our interference should be limited to controlling pain and hæmorrhage; a vaginal tampon, properly introduced, may always be relied upon to fulfil the latter indication. It should be inserted leisurely and methodically, with the aid of a Sims speculum, and generally it should be removed at the end of twelve hours, when a fresh one may be applied, if necessary, after treating the vagina with an antiseptic douche. To allay excessive pain, there is nothing equal to opium, but it should not be pushed to narcotism or to such an extent as to abolish uterine action; ergot may properly be given if the hæmorrhage is excessive and accompanied by inertia, but the more its use is avoided, the better will be the results on the whole. It is better to rely on the tampon, and that of itself stimulates uterine contraction.

If, unfortunately, the sac of the ovum has been emptied of its contents, and the secundines are retained, the question of their removal will come up. There are extremists who are given to energetic interference in all such cases. On the other hand, the timorous trust too long to nature. In such a case, as in most others, the middle course is followed by the judicious. The best practice seems to be not to resort to forcible removal of the remnants of the ovum unless there are particular reasons for doing so. These reasons are for the most part: 1, Signs of septic changes; 2, the undue continuance of hæmorrhage. Under either of these circumstances there should be no hesitation; but the operation should be done without instruments, if possible. In some cases, however, a wire curette is necessary. The patient should be anæsthetized, and, as she lies across the bed, on her back, with the hips brought well to the edge of the bed, the operator should pass one or more of his fingers as far as may be necessary into the uterine cavity and tease away the retained portions of the ovum. The work will be decidedly facilitated if the uterus is gently but firmly depressed by an assistant, who should make pressure on it through the abdominal wall. As a preliminary step, dilatation of the cervix may be necessary, but, as a rule, this should not be accomplished with tents, whether of sponge or of any other material that expands on imbibing moisture. If the fingers will not answer, graduated metallic or hard-rubber dilators should be employed, and, when they are used, the operator should himself make the counter-pressure on the fundus. After the operation is finished, the uterus should be washed out with an antiseptic solution, preferably a straw-colored mixture of tincture of iodine and water, injected through a double cannula.

The after-treatment in cases of abortion hinges chiefly upon enforcing rest for a length of time equal to that usually adopted after labor at term. The special indications do not differ from those met with after ordinary parturition, except that the breasts are not apt to give trouble.

Artificial Abortion.—In this article only criminal abortion will be considered, the induction of abortion for legitimate purposes being treated of elsewhere in this work.

The physician has to look at the matter of criminal abortion from three points of view: his duty to the pregnant woman, his own protection, and the aid he may be able to afford in judicial investigations.

As to his duty to the woman—and, supposing her to ask his assistance in procuring an abortion, this includes his duty to any accomplices she may have—there can be no question but that he is under the most stringent moral obligation, not only to refuse his co-operation, but also to throw all possible obstacles in the way of the crime contemplated, for it is a crime under all circumstances, except when called for to save the woman's life. It necessarily involves the destruction of the embryo, and, potentially, the murder of a citizen. This should be explained to the woman, for in the majority of instances she has no idea of the enormity of the act, and in many cases it will dissuade her from further pursuit of her plan; at all events, he must refuse point-blank to render any aid, and he should not even give a placebo to gain time, for by so doing he may render himself criminally liable, courts having ruled that any attempt at producing abortion, no matter how inadequate, implies guilt; failure, and even proof of the non-existence of pregnancy, being no presumption of innocence, provided only the intent is proved. It is easy to see that, such being the law, a physician may put himself in the power of a designing woman if he is unwary enough to prescribe anything for her, however powerless it may be to produce abortion.

But, suppose abortion has already taken place, and medical services are required for the woman. There need be no hesitation to render them, but the utmost care should be taken that no circumstance calculated to inculpate the physician should remain unexplained. It is

impracticable to enumerate all such circumstances; suffice it to say, that no man of tact will commit an indiscretion in this regard. If the woman dies, the physician is bound to express his opinion as to the cause of death, in the form of a certificate; but, in the opinion of the writer, he is not called upon to act as an informer further than that; if the case comes to trial, he should testify without reserve.

In case of a legal investigation, the following questions may arise: 1. Has an abortion taken place? 2. Was it artificial? 3. If artificial, was it justifiable, criminal, or accidental?

An absolute affirmative answer to the first question can rest only upon proof that an ovum, or some part of an ovum, has been expelled from the woman's genital canal, or has been found therein after her death. When an embryo is found, the case is simple; otherwise, the opinion must rest on the finding of placental or chorionic tissue, for neither the membranes (apart from the villi of the chorion) nor the liquor amnii can be positively identified as products of conception. The appearance of the uterus is not proof, for the enlargement of the organ due to pregnancy, as well as the characters of its inner surface usually found after recent delivery, may be counterfeited by morbid conditions, and, to some extent, even by ordinary menstruation. It must not be forgotten, however, that death may have been due to an attempt at abortion, although there was no pregnancy; hence injuries to the maternal structures should be looked for carefully, quite irrespective of the evidences of abortion. But it is not solely in explanation of the cause of death that this question may come up; a woman may pretend to have suffered an abortion when in fact such is not the case. The same rules of evidence hold good here; however, the whole or a portion of an ovum must be proved to have proceeded from her genital tract.

As to the second and third questions, it cannot always be ascertained with certainty whether the abortion was due to artificial interference, for, even when the fact of such interference is obvious, the abortion may have proceeded from other causes nevertheless. But here the law solves the difficulty, proof of intent being held sufficient for conviction, although the means employed may have been manifestly inadequate; it is not even necessary that pregnancy should have existed, or, if it did exist, that the attempt at abortion should have proved successful. Practically, then, the question is: Were means employed with the intention of producing abortion? These means include the administration of any one of a long list of drugs, mostly drastic purgatives and so-called emmenagogues, among which ergot and oil of tansy are those most commonly employed in this country. These drugs seldom accomplish the purpose for which they were given, and, when they do, it is commonly impracticable to prove the fact of their having been used by evidence discovered on medical examination; it is chiefly, therefore, with reference to the question of mechanical interference that such examination is of value. Most professed abortionists seek to accomplish their purpose by puncture of the fœtal envelopes, and the traces of their work are generally at the same time the evidences of their unskilfulness, in the shape of injuries to either the mother or the fœtus; the discovery of such injuries raises the presumption of criminality, to be dispelled or weakened only by evidence that the injuries might have been inflicted unwittingly, as in the unskilful use of instruments for legitimate purposes. Here, to disprove a criminal intent, it must be shown that a legally qualified practitioner did use instruments for the investigation or treatment of a uterine disease, real or supposed; under such circumstances he may be innocent, and the woman guilty, for she may have feigned uterine disease or concealed the existence of indications of pregnancy: on all these points circumstantial evidence will have to be relied on mainly. It may be added that those authors are unjust who hold that mechanical injury to the uterus indicates the intervention of a third person, for nothing is more certain than that women sometimes produce abortion upon themselves by the use of instruments, or that they occasionally inflict mortal injury upon themselves in this way. Another statement by authors may well be questioned, namely, that the woman is necessarily accessory to the act. It is quite conceivable that a guilty paramour should deceive his victim into submitting to surgical manipulation, wholly apart from any intention of hers to procure an abortion. The fact of an intentional abortion having been proved, the act should not be held to have been justifiable unless it appears clearly to have been undertaken with the manifest purpose of saving the woman's life; the best proofs of such a motive lie in the mother's physical condition and in the fact of a consultation having deliberately decided upon the operation, the physicians concerned being persons of known skill and probity. *Frank P. Foster.*

ABORTION, Criminal.—Abortion is defined as the expulsion of the fœtus at a period of utero-gestation so early that it has not acquired the power of sustaining life. Abortion may be divided into three classes, viz.:—

I. Natural Abortion.—(*a*) Miscarriage, *i.e.*, the expulsion of the ovum or non-viable fœtus. (*b*) Premature labor, *i.e.*, the expulsion of the child after it is viable.

II. Artificial Abortion, *i.e.*, the inducing of premature labor for the purpose of saving the life of the mother and, if possible, of the child.

III. Criminal Abortion, or Fœticide.

Of Artificial Abortion.—In cases where it seems necessary to the physician to have recourse to artificial abortion in order to save the life of the mother, it is advisable, when practicable, to consult previously with another medical man as to the necessity of the operation. If, owing to the death of the child in a case of artificial abortion, the physician should be indicted for abortion or manslaughter, as has often happened, it would be necessary for him to show, first, a necessity for the operation, the life of the mother being at stake and the operation less to be feared than a natural delivery; and, second, that his action was *bonâ fide.* Therefore the physician, before assuming the responsibility of causing an artificial abortion, should take steps to make such evidence readily available in case of an emergency. While the laws do not formally recognize the right of the physician to induce premature labor, yet the judges have always held that medical practitioners are morally justified in inducing premature labor, provided the object be to save the life of the mother, of the child, or of both. By statute, in most States, it is provided that the prosecution need not prove that such a necessity did *not* exist, thus throwing the burden of proof upon the defendant. It is, therefore, highly important that the physician should be prepared for this exigency before assuming the responsibility. A learned writer upon the subject says:[1] "We strongly urge upon medical men (1) not to induce premature labor or abortion without the most mature consideration; (2) not to undertake it until after consultation with a second practitioner; (3) in any case to have the full consent, in writing if possible, of the parent or guardian."

Of Criminal Abortion or Fœticide.—In earlier days the question as to the extent to which the criminality of fœticide was affected by the degree to which gestation had proceeded was one of considerable importance. By the common law a distinction was made between the destruction of an unborn "quick" child, and that of one not yet arrived at the period of quickening. The stage of pregnancy at which the child should be considered "quick" was vigorously debated by different writers and schools without arriving at any general agreement. Among the Stoics it was considered that the soul was not united to the body before the act of respiration, and while the ideas of the Stoics were popular the destruction of a child *en ventre de sa mère* was not regarded as a criminal act. Periods ranging from three days to ninety have been assigned by different writers as the time at which quickening occurs. In England the common law considered life not to commence before the infant is able to stir in its mother's womb, and, until recently, the English law punished with death the procuring of abortion after quickening, while the same crime anterior to

quickening was regarded merely as a felony. Throughout all the European nations, save England, and in some of the States of the American Union, the same pernicious distinction is to-day incorporated in the statutes. However, the tendency of modern legislation is to do away with this distinction. In England, this has already been done by a statute which makes an attempt to abort criminal, even though the woman be shown not to have been pregnant at the time. In the United States, legislators, realizing that the civil rights of the unborn child are protected, that it can have a guardian appointed, and can receive property by bequest or deed, have been inclined to enact laws for the preservation of its personal rights to life. In Massachusetts, the Supreme Court having held that at common law it was no offence to produce abortion, unless there was viability, the Legislature immediately cured the supposed deficiency by statute. The Massachusetts statute presents the law as it is substantially in all the States in which the viability of the child is not regarded as essential to the criminality of the offence. The statute reads as follows:

"[10] Whoever with intent to procure miscarriage of a woman unlawfully administers to her, or causes to be taken by her, any poison, drug, medicine, or other noxious thing, or unlawfully uses any instrument or other means whatever, with the like intent, or with like intent aids or assists therein, shall, if the woman dies in consequence thereof, be imprisoned in the State prison not exceeding twenty nor less than five years, and, if the woman does not die in consequence thereof, shall be punished by imprisonment in the State prison or jail, not exceeding seven years nor less than one year, and by fine not exceeding two thousand dollars.

"[11] Whoever knowingly advertises, prints, publishes, distributes, or circulates, or knowingly causes to be printed, advertised, published, distributed, or circulated, any pamphlet, printed paper, book, newspaper notice, advertisement, or reference containing words or language, giving or conveying any notice, hint, or reference to any person, or to the name of any person, real or fictitious, from whom, or to any place, house, shop, or office where any poison, drug, mixture, medicine, or noxious thing, or any instrument or means whatever, or any advice, direction, information, or knowledge may be obtained for the purpose of causing or procuring the miscarriage of a woman pregnant with child, shall be punished by imprisonment in the State prison or jail not exceeding three years, or by fine not exceeding one thousand dollars."

This is the law as prescribed in the majority of the States of the Union, but in some, notably New York, the old common law distinction between the killing or attempting to kill an unborn quick child and one not quick is still retained; but the courts have not agreed as to the exact stage of pregnancy at which the child should be considered quick. Great latitude is permitted the judge in presenting to the jury the law on the subject. In this connection a celebrated legal writer [2] says: "The weight of medical authority is that quickening is a mere circumstance in the physiological history of the fœtus, which indicates neither the commencement of a new stage of existence nor an advance from one stage to another; that it is uncertain in its periods, sometimes coming at three months, sometimes at five, sometimes not at all; and that it is dependent so entirely upon foreign influences as even to make it a very incorrect index, and one on which no practitioner can depend, of the progress of pregnancy."

Of Medical Testimony in Cases of Suspected Abortion.—It is as a medical expert giving testimony before the courts that the reputable practitioner will most frequently be brought into contact with cases of fœticide. The questions as to whether an abortion has actually been procured, as to the means of inducing it, whether a child found dead was brought to its death by violence, and if so whether the injuries were inflicted before or after birth; all these questions and others of equal importance must mainly depend for their solution upon the testimony of the medical expert. To differentiate between the crimes of infanticide and abortion the services of the medical expert are essential. If a child die after birth, in consequence of injuries received before birth, it is infanticide; but the fact of actual birth must be proved. The fact that the child died in consequence of want of viability resulting from premature delivery is no defence to an action for infanticide if this delivery was caused by the defendant's misconduct in bringing about a miscarriage for the purpose of destroying the child: the test, then, of viability is of the greatest importance to the courts in cases of this nature. To illustrate: In the case of a man indicted for infanticide the evidence showed the child's throat to have been cut, the wound dividing the right jugular vein, and further that the lungs floated in water, showing that they must have been inflated by the act of inspiration; it was shown, however, by the testimony of medical experts that this test merely established the fact that the child had breathed, not that it had been born alive. Numerous instances were cited of children having sustained similar lacerations in the act of delivery. In presenting the case to the jury, Baron Parkes charged them that if they had any doubts as to whether the child was born alive, it would be hardly necessary to go into the evidence in behalf of the prisoner. The jury, without further debate, returned a verdict of acquittal.

Of the Examination by Medical Experts in Cases of Suspected Abortion.[3]—The physician who is required to testify in cases of suspected abortion should endeavor to ascertain whether the abortion has actually been committed, by what means, and at what period. To attain this end, it is well to follow a methodical plan in making the examination. In elaborating this plan it will be well to divide the examination into three classes: 1, The examination of the female during life or after death; 2, the examination of substances expelled from the womb; 3, the examination of instruments or of drugs in the possession of the accused.

1. *Of the Examination of the Woman During Life.*—In making this examination it should be remembered that the duration of the signs of delivery varies greatly in different subjects. They may disappear very rapidly, cases being on record where all signs had vanished in twenty-four hours; or they may be very persistent, having been known to continue for a month. Much depends on the state of health of the mother, and the period of gestation reached. If abortion has occurred at an early period of gestation, the indications are of a very evanescent character, and may, in some cases, be entirely absent. Some of the signs may be simulated by menstruation.

Signs of Abortion in the Living.—A relaxed condition of the vulva and passages, patulousness of the os uteri, the presence of a lochial secretion in the earlier stages, and a white mucous secretion at a later period, together with an acid odor characteristic of puerperal women. The breasts are distended, have a hard knotty feeling, and yield a flow of milk on pressure. The loss of blood produces a general anæmic appearance, and the eyes are noticeably sunken. A peculiar excitement of the pulse, with dryness of the skin, is invariably present. The os uteri is generally perceptibly lacerated. The examining physician should note any signs of violence to the uterus or vagina, also any excessive inflammation of the genital organs. All marks on the body of the woman which may indicate general violence inflicted for the purpose of inducing abortion should be most carefully recorded.

If abortion occurs at an early period of utero-gestation, the indications thereof may be very slight, or even altogether absent. After the third month the insertion of the placenta may be detected by a rough place on the inner uterine wall. In making a post-mortem examination, care is necessary in removing and laying open the uterus, as, if a wound appear, it may be suggested that it was made during the autopsy. Punctures, lacerations, and incisions in the uterus and contiguous organs must be especially looked for; all signs of irritant poisoning in the stomach and intestines, or any inflammation of the bladder or kidneys resulting from the administration of abortive drugs, should be carefully noted. Note, further, any general

marks of violence, especially on the abdomen, also the general appearance of the viscera, *i.e.*, whether they show loss of blood during life such as commonly results from abortion.

2. *Examination of Substances Expelled from the Womb.*—If a fœtus be found, a careful examination must be made to determine its age, whether it was born alive, and, if so, what killed it. It should be carefully examined for punctures or wounds, and should any such be found, try to form an opinion whether the injuries were inflicted during life or after death.

3. *Examination of Instruments or Drugs in the Possession of the Accused.*—In making this examination, note whether the injuries found upon the body of the woman could have been inflicted by the instruments found in the possession of the accused, and whether such instruments show indications of having been recently used. If drugs are found, state whether the symptoms manifested by the woman were identical with those caused by the use of the drug in question.

The results of such examinations as the foregoing are of the utmost importance to the courts of law in the administration of justice. The case of the people against the suspected abortionist must in every case rest upon the testimony of the medical expert. The crime is a secret one; often the law of the State prevents the admission of the woman's testimony. In the graver cases the death of the victim precludes the possibility of her lending assistance to the course of justice. For these reasons many nations have seen fit to commission regular boards of physicians as medical experts, who examine into such cases, and whose testimony alone is received by the courts as that of medical experts. Such is the case in Germany and some other European States. In the United States any physician may testify as an expert, and almost every physician during the course of his practice finds himself called upon for such testimony. Such being the case, it would be well if a formal plan of examination be laid down to aid the medical expert in preparing his testimony. Such a plan has been formulated by Mr. Tidy for the use of the physician called on for testimony in cases of abortion. It is as follows:

MEDICO-LEGAL EXAMINATION IN CASES OF ABORTION.—1. *Examination of the Woman if Living.*—(*a*) Temperament. (*b*) As to the woman's predisposition to abort and the period at which abortion had commonly occurred. (*c*) General state of health. (Note existence of leucorrhœa, excessive menstruation, syphilis, asthma, malignant disease, uterine diseases, etc.) (*d*) Whether woman be well or ill formed. (Note pelvic malformations, effect of tight lacing, etc.) (*e*) Any signs of recent delivery or expulsion of uterine contents. (*f*) Whether any cause can be assigned to account for the abortion, *e.g.*, violent coughing, blood-letting, violent exercise, undue excitement, septic poisoning, violence, administering of medicine, etc. (*g*) All injuries of the genital organs. (Consider whether they could have been self-inflicted.)

2. *Examination of Body of Woman if Dead.*—In making this examination the physician should note: (1) the necessity for care not to mistake the effects of menstruation for those of abortion; (2) to avoid injuring the parts by the knife or otherwise during the autopsy; and (3) to consider the possibility of the injuries having been self-inflicted.

(*a*) Note the existence of any marks of violence on the abdomen or other parts. (*b*) The condition of the genital organs, noting all inflammations, rents, tears, perforations, etc. (If the uterus be injured it should be preserved.) Note also: (1) The condition of the passages (relaxed or otherwise). (2) The condition of the os uteri. (3) Vaginal secretions, and, if present, their character. (4) The general appearance of the breasts, presence of milk, etc. (*c*) Whether there be any signs of irritant poisoning in the stomach, or of inflammation of the bladder, kidneys, rectum, etc. (The contents of the stomach, if necessary, to be preserved.) (*d*) Whether the viscera generally indicate loss of blood during life.

3. *Examination of the Product of Conception.*—(*a*) Nature of the supposed product of conception. (*b*) Consider whether it is merely an evidence of a diseased condition of the membranes, or of the placenta, *e.g.*, structural degeneration. (*c*) If a fœtus be found, determine: (1) whether it was born alive; (2) its probable age, and (3) the cause of death. (*d*) Determine, if there be wounds or other injuries, whether they were inflicted during life or after death.

4. *Examination of all Drugs, Instruments, etc.*—Determine whether said drugs or instruments could be used to produce abortion, and if evidence of such use exists on the person of the woman or the fœtus expelled.

Willis J. Abbot.

[1] Tidy's Legal Medicine, vol. ii., page 160.

[2] Wharton on Criminal Law.

[3] This subject is ably discussed in Tidy's "Legal Medicine," vol. ii. The ensuing discussion of the subject is largely drawn from Mr. Tidy's work.

ABSCESS. [Latin, *abscessus*, from verb *abscedo*, I depart; *abscedo* and *abscessus*, used by Celsus in the sense of the gathering of the corrupted fluids (of the body) into an abscess. Greek, ἀπόστημα. French, *abcès*. German, *Eiterbeule;* though the Germans more commonly use the word *Abscess*.] By the term abscess is meant a collection of pus within the body; this may occur in one of the preformed spaces, or in a new-formed cavity in solid parts. Certain adjective prefixes are used to denote duration, situation, and character of abscesses; thus, as regards duration, they may be acute or chronic; as regards situation, retropharyngeal, perinephritic, perityphlitic, ischiorectal, psoas, etc.; as regards character, the various terms used will be mentioned later. A collection of pus in the pleural cavity has received the special name of empyema, but in the other serous cavities one speaks simply of a purulent pericarditis, peritonitis, ependymitis, or arthritis; a single exception to this is the so-called pelvic abscess, by which is meant a collection of pus in the pelvis, due to a circumscribed peritonitis, the remainder of the peritoneal cavity being shut off by adhesions. Although pus forms the greater part of the contents of an abscess, there may be other constituents present, as blood, shreds of tissue of the part in which the abscess has arisen, foreign bodies, parasites, cheesy material. One speaks of abscesses as primary and as secondary, or metastatic; but, inasmuch as the latter are due to emboli, the term embolic abscess has now wholly superseded the older term metastatic abscess.

An abscess represents the results of a purulent inflammation; occurring in a preformed cavity its walls are, primarily at least, those of the cavity; if in a solid organ, there is in its earliest stage an infiltration of the tissues with round-cells, later a liquefaction of the pre-existing tissues, thus giving rise to the formation of a cavity containing pus. At this stage the wall has a smooth lining, consisting of a vascularized connective-tissue layer, to which the name of pyogenic membrane has long been applied, the supposition being that it was this lining which secreted the pus. That all the pus comes from this source can readily be shown to be erroneous from the fact that in the earlier stages, abundant pus is present before this membrane has formed. Often there is not this tendency to remain circumscribed; on the contrary there is an extension of the pus, the so-called "burrowing," in the direction where the least resistance is offered, soft parts, like muscles, readily yielding, whereas fibrous tissues, like fasciæ, afford a stronger barrier. In the lymph-sheaths of tendons the progress of the pus is very rapid. Abscesses situated near the exterior of the body tend to approach nearer the surface, and are then said to "point;" the skin over the abscess becoming thinned, may finally rupture spontaneously, and thus permit a discharge of the contents. Abscesses in organs having a serous covering often extend peripherally, perforate the capsule, and discharge the pus into the serous cavity, setting up a purulent inflammation of the same. If, however, at the point of rupture two serous surfaces lie in contact, an adhesive inflammation between the two may occur previous to perforation, and thus prevent the escape of the pus into the cavity in which the organ lies. It is in this way that abscesses of the liver occasionally discharge into the bronchi, adhesions occurring between the capsule of the

liver and under surface of the diaphragm, also between the upper surface of the diaphragm and the lung, with perforation of the liver, diaphragm, and lung. Sometimes a sudden and abundant expectoration of pus is the first recognizable indication of an abscess of the liver. Instead of pus being discharged, it may be reabsorbed, either by the individual pus-cells wandering back into blood- or lymph-vessels, or by a fatty degeneration of the cells and then absorption. Occasionally the pus undergoes inspissation, *i.e.*, cheesy degeneration, leaving a crumbling, grayish, mortar-like material; this mass, in turn, may later undergo liquefaction, *i.e.*, saponification, or lime-salts may be deposited in it, forming calcareous masses or plates. Where such changes take place the material occupying the site of the abscess is always surrounded by a dense connective-tissue capsule, separating it from the surrounding parts. A section through a typical abscess shows three distinct portions: in the centre the pus; then the pyogenic membrane; outside of this a zone of the parenchyma, the vessels of which are injected, the tissues œdematous.

Abscesses may be either acute or chronic; the former sometimes called "hot," from the increased warmth of the part; the latter "cold," from the absence of any increase in the temperature.

With regard to the causation of abscess it may be said, that since abscesses are the result of a suppurative inflammation, one must look for their causes in the causes of suppuration. There must of necessity be an irritant, and the next question that arises is as to the nature of the irritant—is it inorganic or organic? or may it be both? It has long been known that turpentine and croton oils, also mercury, when applied externally or injected into the tissues, are capable of setting up suppuration; but it was not proved that they do so in virtue of irritant properties possessed by themselves, and not from any organisms present, until the experiments of Orthmann and Councilman showed that under antiseptic conditions, suppuration followed the injection of such irritants. But, inasmuch as the above causes are of theoretical rather than of practical interest, accounting as they do for scarcely a fraction of abscesses as ordinarily seen, it is obvious that there must be another irritant or series of irritants capable of like results. That these agents are certain lower organisms has been rendered probable by the work of Lister, Billroth, Pasteur, W. Cheyne, Ogston, and above all by Rosenbach, who in a recent monograph has described several forms of micrococci found constantly by him in the pus of acute abscesses, and which, isolated, cultivated and inoculated in animals, were capable of setting up a suppuration. In the pus from cold abscesses, Rosenbach was unable to find any micro-organisms, or more strictly speaking, the culture-tubes remained sterile after pus from such abscesses had been sown in them. Although there is much in favor of the idea that suppuration is dependent upon the presence of micro-organisms, yet it cannot, at the present time, be stated as absolutely proven.

Secondary abscesses are those which are developed at a distance from the primary seat. They are termed embolic, and are usually multiple and small, hence often called miliary abscesses. They are invariably septic, and in most cases the emboli are derived from thrombi undergoing putrid softening. If one wishes to find the source of embolic abscesses, one follows back the circulatory current and searches for a thrombosed vessel. Thus, if such abscesses are present in the lungs, one is likely to find the source either in the sinuses of the brain, the venous plexuses surrounding the pelvic organs, or in the peripheral veins. Embolic abscesses in the brain, heart, spleen, or kidneys, almost invariably have their origin in an ulcerative endocarditis; those in the liver are derived from the radicals of the portal vein. Embolic abscesses probably always contain micro-organisms, and in virtue of these their tendency, when once started, is to extend peripherally, causing a progressive destruction of the tissues in which they lie; the process ceasing only, as a rule, with the death of the individual. In the lung, such abscesses are situated, for the most part, beneath the pleura, and by extension they often perforate the latter, discharging their contents into the pleural cavity, and so setting up a rapidly fatal pleurisy.

A form of abscess seen in hot climates and occasionally in other regions, occurring in the liver, has received the name of tropical abscess. In such cases diarrhœa or dysentery is always an earlier condition, the abscess in the liver representing a secondary result, due to the transfer of septic material from the intestinal mucous membrane to the liver, through the portal vein.

Many of the chronic or cold abscesses are associated with carious arthritis and ostitis, usually tubercular. Frequently in these cases the pus, which is slowly formed, obeys in its further extension the laws of gravity rather than that of extending in the direction of least resistance, as observed in acute abscesses. Thus pus from abscesses associated with caries of the upper cervical vertebræ often appears in the pharynx; from those situated in the lower cervical and upper dorsal regions the pus commonly makes its way downward until the diaphragm is reached, then follows along its surface, appearing externally near the xiphoid. In case the caries affects the lower dorsal or lumbar vertebræ, the pus makes its way downward along the psoas, and gives rise to a fluctuating swelling above or below Poupart's ligament. It should, however, be stated that not all cases of caries of the vertebræ are associated with pus formation. Another form of chronic cold abscess, the pathology of which is exceedingly obscure, is the so-called lymph-abscess. Its usual seat is in the connective tissue of the back—rarely in the muscles. The cavity is, in most cases, a flattened one, and may extend laterally for a considerable distance. The walls are flaccid; the contents a thin pus resembling lymph. The growth of these abscesses is very slow. The term scrofulous abscess is applied to cases in which a suppuration takes place in hyperplastic lymph-glands. A consideration of the diffuse abscess comes properly under the heading of phlegmon or phlegmonous inflammation, what the surgeons formerly called a cellulitis. In connection with the infective disease known as actinomycosis abscesses form, the pus in which presents very peculiar appearances, due to the presence of very numerous, small, sulphur-yellow fungi, which have been proved to stand to the disease in the relation of cause and effect.

The treatment of abscesses, in general, consists of free incisions; washing out of the cavity with an antiseptic solution; free drainage; Lister or iodoform dressing. If within the liver, simple tapping is all that can be done.

W. W. Gannett.

ABSINTHISM.—A term applied to the train of morbid symptoms following the abuse of the liquor called Absinthe.

In its general features Absinthism is almost identical with the alcoholism brought on by the immoderate use of any other alcoholic beverage (vide article Alcoholism, under the heading Insanity); and some observers have even doubted whether any special and peculiar symptoms could be attributed to any of the non-alcoholic ingredients contained in the liquor. Nevertheless, according to most authorities, the evil effects of intemperance not only appear earlier in those addicted to the habitual and excessive use of absinthe than they do in the case of abusers of other alcoholic drinks, but these effects are in themselves of a severer nature, and there is, besides, a more marked disturbance of the nervous system in its various parts. Vertigo, severe headaches, a condition of stupor and of apathetic listlessness, terrifying hallucinations, and epileptiform convulsions are particularly noticeable among the symptoms belonging to the absinthe tippler, and this liquor is especially prone to bring on an early condition of mental decay, and seems to be *facile princeps* in its power to enslave its victim. That the active principles of absinthe (Artemisia absinthium and its congeners) are the agents in causing the special toxic effects of the liquor, has been pretty well established by Marcé in his experiments on dogs and rabbits.

Huntington Richards.

ABSORPTION. *Definition.*—The non-traumatic entrance of a substance through the tissues of a free surface, integument or mucous membrane, into lymph- or blood-channels. Re-absorption of effused lymph (resorption) will be considered under the head of the lymphatic system. Mere imbibition, as of water, by the epithelial cells is not to be regarded as absorption, nor is the term here used so as to include in its application the entrance of heat or other forms of motion.

The elementary processes involved are: (1) Diffusion in the form of osmosis, or diffusion through a porous septum. (2) Filtration, or permeation of a porous septum under pressure. (3) The cataphoric working of electric currents. (4) The complex or vital activities of epithelial cells, similar to those exhibited in secreting glands, but in inverse direction, *i.e.*, from the free surface inward, instead of from the blood or lymph outward. (5) The migratory activity of leucocytes involved in the theory of intestinal absorption of Zawarykin, or the less extreme view advocated by Schäfer and others.

Absorption varies with the locality and the substances soliciting absorption. The skin will be treated of first, then the alimentary canal.

Absorption, by the Skin, of Water and Watery Solutions.—Investigations upon this subject have been made chiefly by three methods. The first consists in weighing the body before and after prolonged immersion in a warm bath. This method is vitiated by the presence of various factors affecting weight. The skin and lungs continue to excrete, and their activity is affected by the bath itself; a considerable amount of water is soaked up by the epidermis without proceeding to real absorption; some remains adhering to the body, especially in hairy regions; a considerable quantity of epidermis scales are rubbed off in wiping dry. Moreover, the water is during the bath in contact not only with the ordinary skin, but also with such mucous or semi-mucous places as the prepuce, glans, and regio analis, which are known to absorb water. The results attained by this method are discordant, and serve only to show that the absorption is not sufficiently great to render negligible the sources of error enumerated above. Fleischer's carefully conducted experiments (1877) illustrate the second method. The arm was immersed in a plethysmograph cylinder, and variations in the quantity of water were indicated in a small tube leading from the cylinder divided into .01 c.c., and susceptible of still finer readings. With suitable vessels, water was also applied to other and larger portions of the body. These local baths were prolonged to between two and three hours. The conclusion reached by Fleischer was that there was no aqueous absorption by diffusion through the intact human epidermis. The third method consists in applying to a part of the integument a solution of some substance capable of either producing a physiological effect, or of being detected in the secretions. The value of the earlier experiments of this form is much impaired by lack of care to exclude absorption by mucous surfaces. This fault, however, only affects positive results. The more recent investigations follow mostly the method of Sereys (1862) and Röhrig (1872 and 1876). The arm or leg is passed through a hole in the partition between two apartments, and the fitting made air-tight. The arm or leg is then sprayed with the solution in one apartment, and the urine passed and examined in the other. Röhrig found iodine in the urine after spraying the human arm with an aqueous solution of potassium iodide, and potassium ferrocyanide in the urine after spraying with a solution of that substance. But v. Wittich (1881), employing the same method with solutions of iodide of potassium of varying strengths, obtained uniformly negative results. So also did v. Ziemssen (1883) with solutions of potassium iodide, salicylic acid, sodium sulphindigotate, and pilocarpin; and there are numerous negative results obtained by older observers, in which solutions of digitalis, belladonna, strychnine, hydrocyanic acid, etc., were employed. These experiments are on the human skin. With rabbits Röhrig states that he obtained absorption from sprays of curare, morphine, digitalin, and iodine; and v. Wittich, though unable to obtain any toxic effects with a strychnine spray, did find iodine in the urine after a potassium iodide spray.

In the foregoing experiments diffusion alone is called into play. Experiments have been made on filtration through the recently removed skin. V. Wittich (1881) was able to carry the pressure up to 67 ctm. of mercury, without obtaining aqueous filtration in either direction with human skin; and the earlier results of Krause were also negative. From such experiments, however, exact conclusions cannot well be drawn respecting the effect of pressure in forcing water through the living skin.

Through its cataphoric working a current of electricity appears to be able to introduce aqueous solutions in small quantities across the ordinary human integument into the vascular channels. H. Munk (1873) used electrodes of clay, wet with an aqueous solution of the substance under trial, and of 10 to 15 mm. diameter. A Grove's battery, with ten to eighteen cells, was used. The direction of the current was frequently reversed. Experiments were made on rabbits, and on Munk himself. With the rabbits the hair was clipped close, but without injury to the epidermis. A rabbit, after ten or fifteen minutes of current between strychnine electrodes, showed heightened reflex excitability; after twenty to twenty-five, spontaneous tetanic spasms. One which had received the current from 18 Groves for forty-five minutes, went into almost uninterrupted spasms, resulting in death half an hour later. In general, the intensity of the toxic effects varied with the strength and continuance of the current. To control, the strychnine electrodes (disconnected) were held on the skin for hours without the least sign of absorption. When Munk passed the current between quinine electrodes placed on his arm for fifteen minutes, quinine was found in his urine for the next twelve hours. With potassium iodide electrodes and a current lasting fifteen minutes, iodine was found in the urine thirty minutes later, increasing for five or six hours. To control, larger pieces of clay, wet with a strong solution of potassium iodide, were bound upon the arm for a day. No sign of iodine appeared in the urine. The outcome of all experiments and observations respecting the absorption of water and aqueous solutions of non-volatile substances by the ordinary human skin, may be stated as follows:

The application of these fluids to the skin does not result in any sensible absorption.

The skin does not probably admit of the introduction of these fluids under pressure (filtration), unless possibly when that pressure is very high.

By the cataphoric action of electric currents, these fluids can be made to permeate the skin in small quantities.

The place of resistance to diffusion seems to be the outer harder layers of the epidermis, and when these are removed, as by blistering, absorption readily takes place.

These statements cannot be applied indiscriminately to animals other than man, nor do they apply to such semi-mucous places as the prepuce, glans or regio analis. Alcohol and alcoholic solutions seem to traverse the skin as little as water. The experiments of v. Ziemssen (1883) on alcoholic solutions of iodine, salicylic acid, carbolic acid, and pilocarpin gave entirely negative results.

The existing evidence seems to be in favor of the belief that oils can be rubbed in, and can carry with them finely divided substances with which they have been rubbed up. But there seems to be considerable variation in results obtained by different experimenters. Lassar[1] finds that in rabbits the skin absorbs oils readily and in large quantities, and that without any pressure or rubbing in, the oil being simply painted over the bared skin or simply poured over the unsheared rabbit. Due precautions seem to have been taken to prevent the animal from licking up the oil. Rapeseed oil, olive oil, cod-liver oil, and petroleum were tried with positive results. Lassar extends his conclusions to the human skin without direct experiments of his own, but calling in the observations of Unna and others, in which, however, the uninjured state of the skin does not seem to be adequately vouched for.

Fleischer in reply[2] calls attention to his previously ob-

tained results,[3] in which salves of veratrin, morphine, and potassium iodide were rubbed into the intact human skin without result, and states that he has repeated the trial with potassium iodide under most favorable conditions, with entirely negative result. There is not, however, any doubt about the absorption of mercury ointments. Scattered and not wholly unimpeachable testimony claims the introduction of morphine and other substances in the form of ointments. There is, on the other hand, considerable evidence that the oleates dissolved in oleic acid or in fats are easily absorbed by the human skin. (See Marshall, *Lancet*, May 25, 1872; Shoemaker, "Trans. Penn. State Medical Society;" Squibb's *Ephemeris*, November, 1882.)

The absorption of volatile substances, such as turpentine and camphor, has been shown by the researches of Lehman (1861) and of Röhrig (1876). The solutions of alkaloids and inorganic salts in chloroform and ether are capable of absorption, as shown by Parisot (1863) and confirmed by Röhrig and others. The same was proved true of solutions of pilocarpin, apomorphine, salicylic acid, and other substances in chloroform, ether, or turpentine forcibly sprayed on the skin.

Gases permeate the skin with ease, as has been proved in the case of carbonic oxide, carbonic dioxide, chlorine, illuminating gas, and chloroform vapor. They are also absorbed when dissolved in water.

Absorption in the Intestine.—The intestine, especially the small intestine, is the principal region of absorption in the alimentary canal. We should be led to expect this from anatomical facts, viz., from the extent of surface insured by the small size and great length, by the folds or valvulæ conniventes, and by the villi, with their plexuses of blood-vessels and lacteal radicles: and this is proved by direct observation and experiment. This extent of surface is of obvious advantage, whatever may be the relation between the shares taken in absorption by the purely physical process of diffusion and filtration on the one hand, and the vital activities of the intestinal epithelium on the other. From the fact that the plexus of blood-vessels in the villus lies outside of the lymphatic radicle, we should expect that the more diffusible substances, such as minerals, sugars, and peptones, would be in large measure conveyed away by the portal system, while it would not be easy to see how the fats would gain entrance to those blood-vessels, or be carried off except by the lymphatic system; these considerations, too, would be entirely independent of the forces involved in the passage through the epithelium of the villus. We should not be led, however, to a too exclusive distribution of the various substances between the lacteals and blood-vessels. We should expect that the blood-capillary network, though it might catch most, would not probably fail to let pass a small quantity of the more diffusible products of digestion; we should not be surprised to find small quantities of minerals, sugars, or peptones in the chyle. If the products of digestion of amyloids and proteids contained less completely transformed and diffusible substances, along with the sugars and peptones, we should find it natural that these should enter largely the lacteals. If, on the other hand, the fats should be largely converted into soaps in digestion, and, as soaps, should pass from the epithelium into the body of the villus, they might be expected to find their way in not inconsiderable quantities into the blood-capillaries. We find the results of direct experiment coinciding very fairly with these anticipations, which rest on general considerations and anatomical facts.

The investigations regarding the absorption of salts are very scanty, and almost wanting in recent times. The observations of Lehman[4] made upon potassium iodide and ammonium sulphocyanate, showed absorption both by lacteals and blood-vessels, and, contrary to what would have been expected, as early in the former as in the latter.

The paths of principal absorption for sugar were investigated by v. Mering (*Arch. f. Anat. u. Physiol.*, 1877, S. 379), who found that the amount of sugar in the chyle was uninfluenced by the ingestion of amylaceous food, while that in the portal blood was increased. Hoppe-Seyler (*Physiologische Chemie*, S. 352) records repeated observations of the fact that while fatty meals cause a rapid flow of chyle in the lacteals, abundant feeding with amyloids and proteids alone have no such effect, the flow remaining quite slow.

With regard to the paths taken by the proteids the observations of Hoppe-Seyler just quoted are in point. Schmidt-Mühlheim (*Archiv f. Anat. u. Physiol.*, 1877) finds that when the chyle is prevented from entering the blood, the proteids continue to be absorbed, and that the effects of proteid feeding in increasing the amount of urea are not diminished.

That fats are absorbed by lacteals in large quantities is shown by the peculiar whitish appearance which they present after a fatty meal. No corresponding appearance of fat is exhibited in the portal system, but the question with regard to soaps, which we know to be formed to a greater or less extent from the fats, is a more difficult one and still unsettled. Lebedeff (*Arch. f. Anat. u. Physiologie*, 1883; "Studien über Fettresorption") found fatty acids in the liver; and, in contradiction to Munk and others, none in the chyle, after feeding with fatty acids, and holds it likely that they were conveyed to the liver in the portal blood.

The mechanism of intestinal absorption doubtless involves, to a certain extent, diffusion or osmosis. The conditions seem favorable for it; a thin and apparently permeable membrane separates the blood from the very different intestinal contents. There is no reason known which should prevent a considerable degree of absorption by diffusion of the more diffusible substances; even filtration may play a part, though probably a small one; the pressure developed by peristaltic action must ordinarily, however, be small. The pumping action of the villi deserves more attention; the muscular fibres of the villi may squeeze out the contents into the lacteals about, and then, there being no return of this fluid, a suction will be developed by the return of the villus to its expanded state in virtue of the elasticity of its tissues, tending to draw in the intestinal contents. But whatever rôle is assigned to diffusion and filtration in intestinal absorption, their action can hardly be deemed sufficient to account for all that takes place, especially in the case of fats; the factor suggested by what we have learned elsewhere is furnished by the epithelial cells. The whole drift of investigations on the physiology of secretion has been to assign the highest importance to the vital activities of the epithelial cell. It is the secreting cell which selects certain subtances from the blood upon one side and passes them out on the other, more or less changed in the process. It is probable that it is the epithelial cell of the villus which takes up what it will from the intestinal contents to pass it out into the body of the villus, possibly, too, somewhat changed, as from peptone to albumen, or from fatty acid to neutral fat. The epithelial cell of the villus will differ, then, from the secreting epithelial cell only in the direction of its action and the nature of the substances which it transports, and, it may be, transforms; the pumping action of the villus would then, independently of any filtration, be of service in removing the pressure against which the epithelial cell would have to work. The results obtained accord with this view. Tappeiner (*Wien. Sitzungsberichte*, Bd. 77, 1878) found that sodium glycocholate and sodium taurocholate were not absorbed in the duodenum or upper jejunum, but that the absorption of sodium glycocholate began in the lower jejunum, and the taurocholate in the ileum. This can hardly be explained under any theory of absorption built merely upon diffusion and filtration, but falls easily in with the assumption of an epithelial action. The greater number of observations have had reference to the absorption of fats; most observers are agreed that the epithelial cells are filled with fat cells during fat absorption, and that the beginning of the paths to the lacteals lies in the cells, not between them. Von Thanhoffer[5] describes and states that he saw in motion cilia-like processes on the surface of the intestinal epithelium in the frog; the activity of these processes seemed to be increased by bile and nervous irritation; the ingestion of fatty particles by the cell is, according to Von Thanhoffer, effected or furthered by the

activity of these processes. Similar moving processes and active amœboid movements on the luminal surface of the cells were seen by Wiedersheim in the intestine of *Spelerpes fuscus* and in young sharks.[6] Wiemer observed the same processes in specimens from the frog, hardened in osmic acid.[7] Spina,[8] from microscopical observations on living tissues, in maggots, frogs, and salamanders, satisfied himself of the active part played in absorption by the epithelial cells of the intestine, and, in the frog, of the skin. The method of transference from the inner end of the epithelial cell to the lymphatic radicle is unsettled. Schäfer has held for some time the view first printed ("Quain's Anat.," 8th ed.) in 1876, that the fat-particles are received from the epithelial cells by the lymph-corpuscles of the reticular tissue of the villus, and carried by them into the lacteal radicle. By others the reticular tissue has been made to play a part, and others still have held that the fat was thrown out by the epithelial cells into the interstices of the villus.

Two observers, Watney and Zawarykin, in contradiction to the belief of almost all other investigators, have held that the fat passes between the cells, not through them. Watney[9] holds that the fat-particles are taken up by a reticulum of lymphoid tissue embracing the epithelial cells, extending up between them. He takes the view, however, that this is no mere diffusion or filtration process, but is active protoplasmic work. While Watney merely would transfer the absorptive process from the epithelial to the lymphoid protoplasm, Zawarykin[10] calls into play the amœboid movements of lymph-corpuscles, which he sees reason to think crawl up between the epithelial cells, fill themselves with fat, and crawl back into the body of the villus. These are both interesting and curious theories, but of little apparent viability.

All recent views reject the explanations of intestinal absorption by mere filtration and diffusion, and have recourse to the vital activities of living cells. If this takes place in fat absorption it is made probable that something of the same kind occurs in the intestinal absorption of other less easily followed substances, and this presumption is favored by the observations of Tappeiner and of Spina referred to above.

The transformation of products of digestion in the passage through the intestinal walls is the subject of active investigation at present, but the results are as yet too uncertain to warrant presentation here.

Absorption in other Scattered Localities.—With regard to other various mucous or semi-mucous surfaces, there has been little careful experimental work. That the conjunctiva absorbs is a matter of daily experience. Respecting the bladder, Sir Henry Thompson[11] states that "the mucous membrane of the bladder appears to have no absorbing power," and injects, in reply to a critic, four drachms of liq. opii sed. into the bladder of a patient with chronic cystitis, on four separate occasions, without sensible effect. Subsequently, in the same patient, twenty minims by the mouth produced marked contraction of the pupil. In the lungs the evidence seems to show that the gaseous absorption is a purely physical process. Fine solid particles entering the alveoli are taken up by round cells, which may be either metamorphosed epithelial cells or wandering cells of the vascular system, and transported by them inward along lymphatic channels to be deposited in the thicker connective tissue septa of the lungs, the bronchial lymphatic glands, or even more remote points; the condition thus produced being known as pneumonokoniosis.

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[1] Lassar: Ueber den Zusammenhang, etc. Virchow's Archiv, Bd. 77, S. 157. 1879.

[2] Fleischer: Zur Frage der Hautresorption. Virchow's Archiv, Bd. 79, S. 588. 1880.

[3] Fleischer: Untersuchungen ueber das Resorptionsvermögen d. Menschl. Haut. Habilitationschrift. Erlangen, 1877.

[4] Lehman: Notiz über die Resorption einiger Salze aus dem Darme. Pflüger's Archiv, Bd. 33, S. 188, 1884.

[5] Von Thanhoffer: Beiträge zur Fettresorption und histologischen Structur der Dünndarmzotten. Pflüger's Archiv, Bd. viii., 1874.

[6] Wiedersheim: Ueber die mechanische Aufnahme der Nahrungsmittel in der Darmschleimhaut. Festschr. d. 56, Vers. d. Naturf. u. Aerzte zu Freiburg, 1 Bd., 1883.

[7] Wiemer: Ueber den Mechanismus der Fettresorption. Pflüger's Archiv, Bd. 33, 1884.

[8] Spina: Untersuchungen über die Mechanik d. Darm- und Hautresorption. Wien. Sitzungsb., Juli, 1881.

[9] Watney: On the Minute Anatomy of the Alimentary Canal. Phil. Trans. London, 1876.

[10] Zawarykin: Ueber die Fettresorption im Dünndarm. Pflüger's Archiv, Bd. xxxi. 1883.

[11] Thompson: Diseases of the Urinary Organs, Fifth Ed., p. 301. 1879.

ACANTHOCEPHALA (thorny-headed worms) form an order of helminths including only one genus, the echinorhynchus, of which there are several varieties, which infest swine, monkeys, birds, etc., but only two cases have been reported of their occurrence in man. In one there is some dispute as to the variety; the worm was found in the small intestine of a boy, and by Lambl, the reporter, was called *echinorhynchus hominis*. The second case was reported by Welch as occurring in an English soldier returned from India. Cobbold expresses his belief that this worm was a pentastoma.

Fig. 22.—Echinorhynchus Hominis, × 10 times. (Lambl.)

The echinorhynchus is characterized by a retractile head armed with several rows of hooks, by means of which it retains its position in the intestines or bores its way through; its body is elongated, cylindrical, and pointed behind.

E. gigas is found in the hog; the mature female may be two feet long by one third of an inch broad; the male is about three inches long. The embryos infest the larvæ of the cockchafer, as their temporary host, before entering the swine.

Chas. E. Hackley.

ACARI, or mites, belong to the class of Arachnidæ. Two varieties chiefly infest man. The *acarus scabiei*, sarcoptes hominis, or itch-mite, is nearly circular in shape; the female is from one-fourth to half a millimetre in its long diameter; the male is rather smaller; the body is whitish; young ones have six legs till they change their skin, subsequently they have eight legs, two on each side of the head, and two on each side behind. Of the front feet the two next the head have suckers, the others have projecting bristles. There is an intestinal canal opening posteriorly, but no respiratory organs have been recognized. The female burrows under the skin, sometimes to the length of an inch; this burrow is called the cuniculus; as she progresses she lays eggs, perhaps ten or fifteen in a furrow; in a week or two these hatch into young acari, ready to begin work. By boring into the skin they cause itching, which induces scratching, and this probably develops the nodules, vesicles, and pustules, which are found on patients with itch or scabies, of which disease they are the sole cause. Female acari are stated to live three or four months.

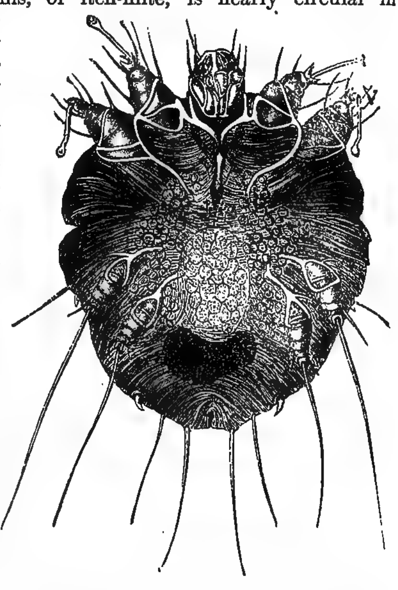

Fig. 23.—Acarus Scabiei. Female. Front feet with suckers; hind feet with bristles; posteriorly sexual openings. Magnified. (Gustav Behrend.)

The disease may be transferred from one person to another by the passage of a pregnant female or of young acari, which subsequently breed. This transfer is more apt to occur in bed, when patients can scratch readily and tear the insects out of their burrows. The diagnosis is rendered certain by opening a cuniculus with a needle and finding the acarus and eggs.

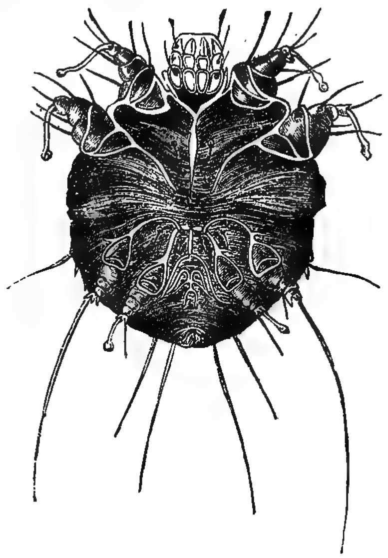

FIG. 24.—Acarus Scabiei, Male. Front feet and two hind feet with suckers, other hind feet have bristles. Magnified. (Gustav Behrend.)

Treatment consists in killing the insects and eggs by frictions with green soap and sulphur, petroleum, balsam of Peru, etc. Hebra thought that the insects in clothing, etc., soon died, and that it was hardly necessary to bake these articles for the purpose of disinfecting.

Acarus folliculorum (entozoon fol., steatozoon fol., demodex fol.) is a minute whitish parasite, from one-tenth to three-tenths of a millimetre long by one-fortieth of a millimetre broad, which is found in the orifices of the sebaceous glands of the nose and in the hair-follicles. It occurs in many people, especially in those with greasy skins, and may often be obtained by scraping the skin with a spatula. Under the microscope it is found to consist of a cephalo-thorax about one-fourth the whole length, the other three-fourths constituting the abdomen. The head has two palpi with a proboscis between them ; on each side of the thorax are four feet with claws. A species is described with but three feet on each side ; these, however, are probably young ones, as in acarus scabiei. There may be from two to a dozen in one follicle ; they are not known to have any injurious effect.

FIG. 25.—Acarus Folliculorum. Tail is foreshortened. Magnified.

Charles E. Hackley.

ACAROIDES, GUM: BOTANY BAY GUM ; RESINA LUTEA.—By these names are designated two or three closely connected aromatic resins, obtained in Australia from several species of the small and peculiar genus *Xanthorrhœa* (*Xantorrhœa* Lüerssen). The genus, by some botanists considered to belong to the *Liliaceæ*, but placed by Bentham and Hooker among the *Juncaceæ*, consists of less than a dozen species of sometimes low, oftener shrubby, or even arborescent plants, with the general appearance of screw pines. Stems leafy, frequently containing an abundance of yellow or reddish resinous juice ; leaves long, linear, rigid, brittle, with dilated, imbricated, persistent bases. Inflorescence a long terminal close spike of small flowers. Perianth persistent, its segments distinct, the outer glumaceous, the inner petaloid or transparent. Ovary three-celled, ovules few ; capsule coriaceous dehiscent The resinous sap exudes spontaneously, and hardens upon the stem in tears or masses. Two principal varieties of the "gum" are distinguished ; the red, in deep-red lumps or fragments resembling lumpy specimens of dragon's blood, having a weak odor of benzoin, and a spicy cinnamon-like taste ; the yellow, in orange-yellow pieces or tears, having a strong benzoin odor.

The balsam, for such it really is, contains, besides some bassorin and uninteresting ingredients, a large proportion of *cinnamic acid* and some *benzoic acid*. Decomposed with melted potash parbenzoic and protocatechuic acids, pyrocatechin and resorcin are formed. In nitric acid the balsam dissolves readily, and yields abundance of picric acid, together with oxalic and nitrobenzoic acids.

The *xanthorrhœa* resins have long been used in Australia as a remedy for gastric troubles, intestinal catarrhs, diarrhœas, etc., and are occasionally prescribed in this country for similar conditions ; but their principal uses are in the arts as a source of picric acid, and in the manufacture of lacs and varnishes.

Dose, from one-half to one gramme (gr. viij. ad xvj.). It may be given in alcoholic solution.

ALLIED PLANTS. — The *Juncaceæ* (rush family) is a smallish order, of which juncus is the principal genus ; they differ from *Liliaceæ* chiefly in their habit and membranous perianth ; they have no important medicinal qualities. The *Xanthorrhœas* resemble some *Liliaceæ* in habit (*Aloe, Yucca,* etc).

ALLIED DRUGS.—Benzoin, balsam of Tolu, balsam of Peru, etc. *W. P. Bolles.*

ACCLIMATION. When any animal, brute or human, is removed from the environment to which he and his ancestors have long been accustomed, a considerable disturbance of the whole economy is liable to ensue. The process of evolution has developed certain organs and certain functions in accordance with the requirements of those circumstances under which his race has found itself, and when he is suddenly transplanted into new conditions some of his faculties become without occupation, while others hitherto uncalled upon, and therefore undeveloped, are suddenly subjected to a demand to which they are quite unable to respond. The process of accommodation of the individual to new conditions of climate is known as acclimation or acclimatization. These conditions include temperature, moisture, morbific germs, elevation, sunshine, food, and other less tangible factors. Such elements as are connected with the social rather than the natural environment, as, for instance, education, the standard of public morality, and the avocation or means of livelihood, while in any radical change that they may undergo, profoundly affecting the individual, are yet to be held distinct from the conditions to which acclimation properly refers.

No other animal is so facile in his accommodation to changes of climate as man. The lower animals and plants often do not recover from the effects of transplantation for several generations. The Société d'Acclimatation of Paris has for years being carrying on an extensive zoölogical experiment, in its gardens, on the domestication of foreign animals and plants which it is believed can be made useful to European countries. The record of their failures and successes is embodied in the numerous volumes of their reports. Man's comparative immunity from the disastrous effects of changing climate is due in part to his ability, by an intelligent prevision of the dangers which are to beset him, of guarding against them. The records of arctic explorers present abundant evidence of the ability of the denizens of temperate climes to endure winters in which the thermometer averages from 40° to 50° F. below zero. On the other hand, Europeans have lived in health and cheerfulness on the banks of the Senegal when the thermometer in their tents stood at from 120° to 130° F. Men endure extremes of barometric pressure ranging from that of several atmospheres, as found in caissons, to the tenuity of the air experienced at great elevations. In the Himalayas men have lived at the height of 15,000 feet, and Humboldt even went to the elevation of 19,286 feet, where he remained for a time without ill effects ; but where no animal but a dog would follow him, and this creature quite lost the power of barking.

The differences in the facility of acclimation at various

points in the same latitude are shown by an article reprinted in the *Popular Science Monthly* for July, 1884. Between 30° and 35° N. latitude, Europeans acclimate much less readily than in the same latitudes south. Algiers, for instance, is vastly more difficult for the European to live in than Cape Colony, yet both places are about latitude 35°. The Argentine Confederation and New South Wales are more healthy than the East and West Indies, which are of the same latitude. The mortality of the French and English troops has been found to be about eleven times as great at foreign stations in the northern as at those in the southern hemisphere. The chief cause of the difference is in the prevalence of miasmatic fevers so deadly to Europeans. Those fevers in the northern hemisphere occur even in high latitudes, while south of the equator they do not extend beyond the tropic. The island of Tahiti, for instance, about latitude 18° S., is quite exempt from these fevers. The records of the French and English soldiers on foreign service show, in South America, a sickness from malarial fevers of 1.6 in 1,000 men per annum; while in similar latitudes in the northern hemisphere, the number of such cases annually is 224 per thousand.

To persons removing from one point to another within the temperate zone, one principal obstacle to acclimation is change (especially diminution) in barometric pressure. Many persons on going to an elevation of not more than 6,000 feet experience a sense of constriction in the chest as well as across the liver and stomach. The pulse is quickened, as is also the respiration. The individual sometimes feels that he cannot take a long breath, and is often testing himself to see if he can do so, but the act does not relieve the air-hunger. Slight exertion causes fatigue and the sleep is disturbed and fitful. If there was any pre-existing heart trouble, the condition may soon become perilous. Anything like a congestion of the internal organs adds to the danger of ascending to high altitudes. If the unpleasant symptoms continue after a day or two of perfect rest, it is advisable to make no further attempt to secure acclimation.

The acclimation of Europeans in tropical countries may be simply meteorological, as in Tahiti and other kindly climates of Polynesia, where no diseases lie in wait for their prey, and where the new-comer, but for the changed condition of the temperature and a certain physical and mental lassitude accompanying it, lives much as he does at home. By reason of the insalubrious character of most places in the tropics, however, acclimation becomes more or less a pathological process. Yet even in such countries acclimation may take place without the intervention of any morbid process whatever. On the other hand, foreigners sometimes pass through an attack of a seemingly specific fever, which, when it does occur, seems to facilitate acclimation, though it is by no means essential to the accomplishment of that process. This fever of acclimation is thus described by M. Rufz de Lavison ("Étude sur la population de la Martinique, 1850–62"): "When neither yellow nor intermittent fever nor dysentery is in the air, a fever often shows itself, characterized by headache, heat, coloring of the skin, thirst, great restlessness; in fact, the complexus of symptoms belonging to yellow fever. If the latter disease were epidemic, this would be likely to be diagnosticated as yellow fever. But all the symptoms yield at once to treatment, and convalescence is established by the third or fourth day. It is a common belief of the people of Martinique that those persons who do not pay this tribute to the climate, will be sicker in any subsequent attack of disease than those who have had the acclimating fever; but it certainly is not indispensable to successful acclimation, and affords no immunity against yellow fever."

The diseases to which a European is especially subject on removing to the tropics are yellow fever, dysentery, hepatitis, anæmia, and malaria. The first of these, yellow fever, constitutes the greatest immediate danger for the unacclimated stranger. The Creole population, as is known, are largely exempt from susceptibility to this disease, though even they, after having resided for a time in the temperate zone, have to go through an acclimation on their return before they are safe from the disease. Their acclimation is more quickly accomplished, however, than that of the European. Immunity against this fever is gained by a previous attack, and also by having passed through an epidemic of it, even without having contracted the disease. The time necessary to secure absolute safety against yellow fever is variable. The other tropical diseases which impede acclimation, dysentery, hepatitis, etc., afford no security against yellow fever.

Dysentery, which is, perhaps, next to yellow fever, the most fatal obstacle to the acclimation of Europeans in the tropics is rarely, except in great epidemics, fatal at the first attack; but with successive years it is apt to recur, either as dysentery or as chronic diarrhœa. The British Admiralty, on the theory that the mortality of the colonial troops from this cause is in direct ratio of the period of their stay in the tropics, removes and replaces such garrisons at short intervals, while the French Government sends annually to her colonies transports to carry away those soldiers who have become enfeebled by relapses and recurrences of dysentery. A certain number of cases never can become acclimated to this disease, and find relief only by a return to temperate climes.

Another obstacle sometimes fatal to acclimation, but of rarer occurrence, is hepatitis. This may be either primary, due to heat or malarial infection, in the latter case the enlargement of the liver being analogous to the accompanying splenitis; or the hepatitis may be secondary to dysentery, in which case abscess of the liver may result with usually a fatal ending. These hepatic abscesses are said to be more common in Europeans than in Creoles after a dysentery. Other liver diseases, cancers, hydatids, and icterus, due to affections of the gall-bladder and ducts, are said by Dr. Saint-Vel, in his work, "Hygiène des Européens dans les Climats Tropicaux," etc., to be rarer in the torrid than in the temperate zone, in spite of the common belief to the contrary.

A degree of anæmia may be considered physiological in hot countries. But it not unfrequently becomes excessive, interfering with the nutrition of the body and combining with a certain amount of malarial poisoning, and perhaps also of hepatitis, to impart the doughy, pale, and sallowish tint not uncommon in those who have lived long in the tropics. This anæmia, sometimes amounting quite to a cachexia, is most extreme in the immediate neighborhood of the equator, growing less with every degree of latitude, and is by no means confined to the white race, though it is only as it occurs to Europeans seeking acclimation that it deserves mention in this connection.

Intermittent and remittent fevers and other manifestations of malarial cachexia are the obstacles which most commonly stand permanently in the way of acclimation. Recent observations have shown that malaria exists, at least in the northern hemisphere, nearly as far up as the arctic circle, and the deadly nature of the Tuscan Maremma (lat. 43°) has even given a name to the disease. Still, the most virulent types of the disease are of tropical origin. An individual may resist these influences for a time, to fall a victim without any apparent change either in his own carefulness or in the nature of the surrounding miasmatic influences. Malaria is not confined, like yellow fever, to the coast regions, but is distributed widely. High altitudes are not exempt from it, and it was found by Curran even on the chain of the Himalayas. Still, it is more common in lower levels where vegetation once covered with moisture is left by a subsidence of the water exposed to the atmosphere. There are some regions, as, for instance, parts of Senegal, Madagascar, and French Guiana, where the malarial influence is so strong that, while individuals have overcome it, it may be said that, as a race, Europeans hitherto have failed to become acclimated.

In passing from the tropics to the temperate zone, the obstacles in the way of acclimation are much less than to those who emigrate in the other direction. The transition of seasons from the heat of summer to the cold of winter has a tonic effect, and is favorable to those suffering from anæmia, hepatitis, and malaria. Certain inflammatory chest affections, however, are liable to be caused

in Creoles by a northern winter, as well as some cutaneous diseases, dependent perhaps on the change in the amount of perspiration. It is often claimed that persons removing to the temperate zone are in special danger from phthisis. Dr. Saint-Vel (loc. cit.) says that the reverse of this is true. Some negroes die of tuberculosis in the hospitals, but there are usually circumstances of special exposure in these cases, while those negroes who are well cared for and live at service are remarkably free from phthisis. Confusion has perhaps been made of the negro with the monkey in this respect; but the tuberculosis so common in the latter animal is due to his confinement and to other conditions not obtaining in the case of the negro. The experience of all the Northern States of our country shows that the negro acclimates well in the temperate zone, but observations are wanting as to his power of adapting himself to really cold climates.

The Creoles residing in France are particularly long-lived. Their acclimation is said to be more readily accomplished than that of whites returning after a long residence in the tropics; but, as a whole, the effects of removal from lower to higher latitudes is more beneficial than that of moving in the contrary direction. Arctic animals do less well in temperate regions than those from the tropics.

Hygiene of Acclimation. — Hygiene can do something to overcome the obstacles in the way of acclimation. It is especially important in combating dysentery, anæmia, and malaria. Contrary to what has been sometimes taught, a robust frame is an assistance to acclimation. The immigrant to the tropics should, if possible, reach his destination in the cool season, that the transition may be as moderate as possible from his native clime. For the same reason the tropical emigrant should reach the temperate zone in the summer. In going to the tropics one should not deprive himself wholly of a meat diet, though of course less meat and very little fat are required. The food should be sufficient in all its constituents to keep up the strength. Alcoholic excess is to be especially avoided. The light wines are much preferable to spirits. A slight diarrhœa is to be checked at once, as otherwise it may run on to the severe chronic intestinal fluxes. The dwelling should be situated high, with the sleeping-room on the second floor. Alluvial bottoms are to be avoided as places of abode, and the domicile should not be placed in the track of breezes blowing over marshy districts. Exposure to the night air is unwise, especially when there is a fog hanging about. Food should be taken before going out in the morning, and a daily dose of quinia should be made use of.

Direct exposure to the equatorial sun during the middle of the day should be avoided. Only the natives can withstand its fierceness. On the other hand, draughts, especially of night wind, should be as carefully avoided as in temperate climes. While the clothing should of course be light, it should be of cotton rather than linen, and merino undergarments should be worn, and changed frequently in order to keep the large amount of transuded moisture absorbed. Nostalgia, which retards acclimation, should be avoided as far as possible. If society is wanting, work must be relied upon to take up the mind. It is said that the workers acclimatize more readily than the idlers in hot countries. Of the various forms of exercise, which is always so important from a hygienic point of view, riding and driving are especially desirable in warm countries. Cool and cold baths daily are of use. The advantages of hydrotherapy are often combined with those of high elevation in the sanatoria which are located in the mountainous districts (where such exist) in many warm countries, and whither the half-acclimated European repairs from time to time with much benefit to paludic, dysenteric, and hepatic affections. Finally, if dysentery obstinately recurs, in the high altitude, or if the system does not throw off miasmatic impressions, it is better, after a reasonable time, to abandon the attempt at acclimation and return to a temperate climate. The ocean voyage will be likely to cause some relief, and after a reconstitution of the bodily powers in the home country, a second attempt at acclimation may be more successful.

Charles F. Withington.

ACCOMMODATION AND REFRACTION.

Physiology.

Refraction.—1. The term refraction refers in physics to the deviation of a ray of light from its straight path on passing from one transparent medium into another of different nature. In physiological optics, however, this term is used with a special significance, denoting the relation of the focal length of the eye to the position of the retina. The eye has a normal, or emmetropic (from ἔμμετρος, according to measure, and ὤψ, eye), refraction, if images of distant objects are sharply defined on the retina; the refraction is myopic, or near-sighted, if distant objects form images in front of the retina; while hypermetropia is that refractive state in which images of distant objects can only be sharply defined behind the actual place of the retina. Any refractive state other than emmetropia is referred to in general as ametropia (from ἄμετρος, disproportionate, and ὤψ, eye).

The eye of all vertebrates is an optic instrument, the principle of which is illustrated by the photographer's camera obscura. By means of a convex lens, the rays of light coming from the different points of external objects are so reunited as to form inverted, but geometrically correct, images of those objects on a screen. The screen is the retina, while the convex lens is constituted by all the transparent media of the eyeball.

A correct knowledge of the optic properties of the eye is not possible without some familiarity with the laws of physical dioptrics. Hence we must begin with a *résumé* of the laws of the refraction of light. In order to keep this article within the allotted space, we will not attempt to follow out the mathematical deduction of all the various formulæ of which we must make use. For the complete mathematical proof of all the statements the reader must consult some of the works mentioned in the bibliography, especially those of Helmholtz and Donders.

The paths of the rays of light entering the eye, and the influence of the different media upon them, can be deduced from the following optic principles:

2. *Law of Refraction.*—From every point of a luminous or illuminated object there proceed rays of light in all

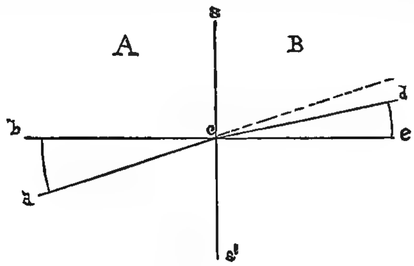

Fig. 26.

directions. Every ray pursues a straight course as long as it passes through a uniform medium. When a ray passes from one transparent medium into another of different optic properties, it is refracted or deflected from its straight path, except when its original direction is vertical to the surface of the second medium. The extent of deflection depends on a specific property of each medium, viz., its refractive power. The relation of the refractive power of any one medium to that of another is termed the refractive index, and is usually designated by the letter n. Air is taken as the standard of comparison, and its index of refraction is called 1. Compared with air the refractive index of water is 1.334; of crown-glass, 1.533; of flint-glass, 1.664. A medium having the greater refractive index is said—in a somewhat loose manner—to have a greater optic density than another rarer medium.

The extent to which a ray of light is deflected from its straight path, by refraction, depends on the angle at which it strikes the surface, as well as on the refractive indices of the media.

Let A, in Fig. 26, be air, with the refractive index $= n$,

and B be glass, with the index $= n'$, the two being separated by the surface $s\,s'$. A ray of light, having the direction $a\,c$ in the air, will be bent in the direction $c\,d$ on entering the glass. If we erect the normal $b\,c\,e$ vertical to the surface at the point c, the angle $a\,c\,b$ is the angle of incidence of the ray $a\,c$; the angle $e\,c\,d$ is the angle of refraction. The latter is here smaller than the former, for, in the denser medium, the refracted ray is bent toward the perpendicular. The relation of one angle to the other depends on the relation of the refractive indices of the two media, so that the sine of either angle is to the sine of the other inversely as the index of the corresponding medium is to that of the other, or

$$\frac{\text{sine } a\,c\,b}{\text{sine } e\,c\,d} = \frac{n'}{n} \qquad (1)$$

Since the sine of an angle zero is likewise zero in value, it follows that when the incident ray is itself perpendicular to the refracting surface, it continues to be perpendicular after its entrance into the second medium, *i.e.*, it is not deflected at all from its course.

The path which a ray describes in passing through one or more refracting surfaces is the same, whether that ray travels forward or backward from any given point in its course.

3. If the denser medium is in the form of a plate bounded by parallel surfaces and surrounded by the same rarer medium on both sides, a ray, after passing through the plate, follows a direction parallel to its original course, but is displaced laterally.

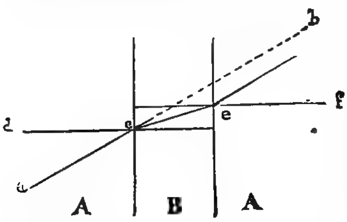

FIG. 27.

For in Fig. 27, where A represents the air, and B the plate of glass, the ray $a\,c$ on entering the glass is bent toward the perpendicular $d\,c$ to an extent exactly counterbalanced by its deflection from the perpendicular $e\,f$ on leaving the glass. Hence the ray $e\,b$ after passing through the glass is parallel to the prolonged direction of the original ray $a\,c$.

4. *Refraction by a Single Refracting Surface.*—When the denser medium is bounded by a convex spherical surface, all rays (except one) coming from any point in the rarer medium are deflected in such a manner as to be less divergent after their refraction than they were before. The one ray not deflected is the one striking the surface vertically, hence coinciding in the radius or axis of that point of the surface. It is hence termed the *axial ray*.

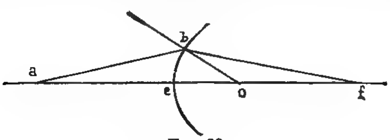

FIG. 28.

In Fig. 28, let a be a point in the air from which rays proceed toward the convex surface $b\,c$ separating the air from the glass. Let o be the centre of curvature of the refracting surface $b\,c$. Let the ray $a\,c$ be vertical to the surface, *i.e.*, coinciding with the direction of the radius $o\,c$; it will hence not be deflected from its course. The ray $a\,b$ is, however, refracted. If $o\,b$ is the radius of the surface, and is hence vertical to the point b, the angle of refraction $f\,b\,o$ can be found by the formula

$$\text{sine } f\,b\,o \;:\; \text{sine } a\,b\,d = n : n'$$

It is evident from Fig. 28, that if the point a be not too near to the refracting surface, the refracted ray $b\,f$ will verge toward the undeflected axial ray, and will meet it in some point which we will designate f. It can be shown by a mathematical analysis, that not only this one ray, but that all rays proceeding from the point a toward the convex surface $b\,c$ are so refracted as to meet the axial ray at the point f, provided we limit our analysis to those rays only which are not very oblique to the axis, and do not strike the surface far from the axis. With this provision, the point f is the collecting point of all rays coming from a; the point f is therefore the image of the point a. If we trace, however, the course of the rays which are very oblique to the axial ray, or which strike the surface far from its axis, we will find that they meet the axial ray at various points different from f. Such a want of exact reunion of all the rays, when too large an extent of the refracting surface is exposed, constitutes the fault of optic instruments known as *spherical aberration*. The refraction of such very oblique rays is represented, in a somewhat exaggerated manner, in Fig. 29.

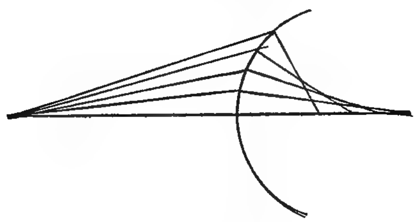

FIG. 29.

5. *Focal Length.*—When the luminous point is situated in the rarer medium at a distance infinitely great compared with the dimensions of the refracting surface, the different rays emanating from that point strike the refracting surface with so little divergence as to be practically parallel to each other. These parallel rays are rendered convergent by their refraction. The point where these refracted rays meet is called the principal posterior focus, and its distance from the refracting surface is the posterior focal length. This distance, designated usually as F'', depends on the relative indices of refraction of the first and second medium and on the radius of curvature of the refracting surface. If we call this radius r, the formula for the posterior focal length is

$$F'' = \frac{n'\,r}{n' - n} \qquad (2)$$

The plane drawn through the posterior focus vertical to the axis of the refracting surface is called the posterior focal plane.

As the luminous point moves nearer to the refracting surface, so as to make the incident rays more and more divergent, their focal reunion recedes further from the surface, until a certain point in front of the convex surface is reached, the rays proceeding from which are so divergent that they can no longer be rendered convergent by their refraction, but only parallel. Their point of focal reunion may then be considered as infinitely far behind the surface. The point in front of the surface from which these rays proceed is the principal anterior focus, and its distance from the surface, which we will call F', is the anterior focal length. A vertical plane laid through it is the anterior focal plane. F' can be found by the formula

$$F' = \frac{n\,r}{n' - n} \qquad (2a)$$

A comparison of formulæ (2) and (2a) shows that the anterior and posterior focal lengths are not alike under the circumstances, but that

$$F' : F'' = n : n' \qquad (2b)$$

Remembering that the path of rays is the same, whether these rays travel forward or backward, the anterior focus can also be defined as the point in which rays unite, which proceed parallel to each other in the denser medium toward the refracting surface.

6. The distance of the focal reunion from the refracting surface can be calculated for any set of rays, coming from any point, if we know the distance of that point from the surface, and also the anterior and posterior focal lengths of the refracting surface. If f' be the known dis-

tance of the luminous point, the distance of the corresponding focal reunion f'' will be

$$f''=\frac{F''\ f'}{f'-F'} \qquad (3)$$

Conversely the distance of a luminous point, f', can be found, if we know the distance of its corresponding focal reunion or image f'', according to the formula

$$f'=\frac{F'\ f''}{f''-F''} \qquad (3a)$$

A very convenient formula for finding the place of the focal reunion of rays coming from a point at a known distance can be obtained by the transformation of (3) and (3a). If we designate the distance from the luminous point to the anterior focus, viz. : $f'-F'$ as l' (counting l' negative if f' is nearer to the surface than F'), and the distance from the posterior focus to the point of focal reunion of the rays in question, viz.: $f''-F''$ as l'', then

$$l'\ l''=F'\ F'' \qquad (3b)$$

In all these instances the relation of luminous point and corresponding image can be reversed without change of position; in other words, if the point x is the image of the point a, then for rays proceeding in the reverse direction, a is also the image of the point x. Any two points having such a relation of luminous point and corresponding image, are called *conjugate points.*

7. *Virtual Image.*—When the rays, coming from a point nearer than the anterior focus, strike the refracting sur-

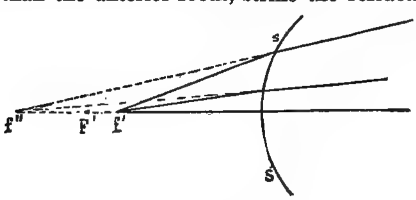

FIG. 30.

face, their divergence is too great to be entirely overcome by the refraction. They cannot therefore be united to form an actual image; but if their direction, after the refraction, be prolonged backward, their prolongations meet to form a *virtual* image. The focal reunion of such rays is therefore negative.

Thus, in Fig. 30, if F' be the principal anterior focus of the refracting surface $s\ s'$, and f' the luminous point, the rays proceeding from f' will have a divergence after their refraction, as if they came from the point f'', which is therefore the image of f'. Since f'' is on the same side of the surface as f', its distance is counted negative. It can be determined by formula (3a) or (3b).

8. *Formation of Images.*—Since an object is made up of an infinitely great number of points, and since of every such point in front of the refracting surface an image is formed somewhere behind the surface, therefore an image must also be formed of the entire object. From every point of the object there proceeds one ray, which is not bent from its course by refraction, viz. : the ray which strikes the surface perpendicularly, and hence coincides in direction with the radius of the point of the surface. Such rays are termed *rays of direction* Since all other

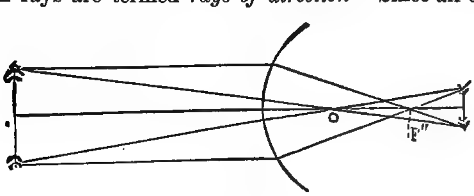

FIG. 31.

rays proceeding from any one point of the object meet the ray of direction at the corresponding distance of focal reunion, the image of every point of the object is situated somewhere in the path of the ray of direction coming from that point. Since every ray of direction coincides with one of the radii of the refracting surface, the rays of direction must, therefore, like the radii, intersect at the centre of curvature of the surface. Since the focal length of a refracting surface is always greater than its radius, according to formulæ (2) to (3a), therefore the actual images of objects farther off than the anterior focus are formed somewhere beyond the point of intersection of the rays of direction, and are hence inverted. This is illustrated by Fig. 31.

The point where the rays of direction cross, viz.: the centre of curvature of the surface, is also called the *optic centre.*

9. When the object lies in a plane vertical to the axis of the refracting surface, all points of the object near the axis are sensibly at the same distance from the refracting surface, as measured by the length of the rays of direction. Their images are therefore likewise situated at

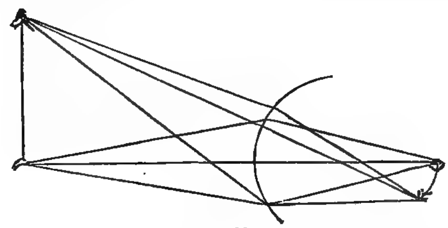

FIG. 32.

equal distances behind the surface, and hence lie in a plane vertical to the axis. But this is true only as long as the angle included between the ray of direction coming from that point of the object, and the axis of the refracting surface is so small as to permit the substitution of its chord for its arc without practical error. In the case of objects of dimensions exceeding this limit, the images lie in a curved line, with the concavity toward the refracting surface, as shown in Fig. 32.

Such extensive images are blurred, on account of spherical aberration. (See Section 4.)

10. *Circles of Diffusion.*—An image is sharply defined only in the plane of focal reunion of the rays. In any plane anterior to this the rays are not yet united; in any plane

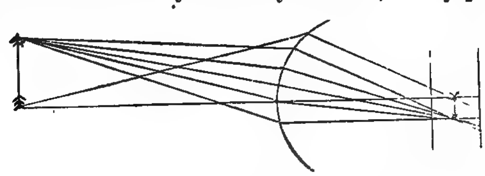

FIG. 33.

posterior to this the rays diverge again. Hence a screen placed in front or in the rear of the focal reunion receives a blurred image, since every point of the object is represented—not by a single point—but by a circle of diffusion. The size of the circles of diffusion increases with the distance of the screen from the point of focal reunion in either direction, and with the extent of the refracting surface through which rays pass. This is evident from Fig. 33.

11. *Size of Images.*—The size of the image is to the size of the object as the distance of the image from the optic centre is to the distance of the object from the same point.

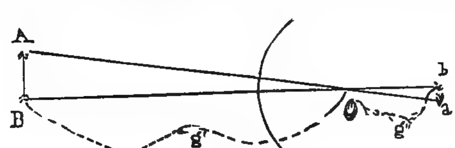

FIG. 34.

If we designate, in Fig. 34, the distance of the object $A\ B$ from o, the optic centre, as g', and the distance of the image

$a\,b$ from o as g'', we can express the relation of size by the formula

$$a\,b : A\,B = g'' : g' \tag{4}$$

the truth of which is evident from the similarity of the two triangles $A\,B\,o$ and $a\,b\,o$. For certain calculations the relation of size can be more conveniently stated as

$$a\,b : A\,B = f'' - F'' : F'' \tag{4a}$$

in which formula F'' is the principal posterior focal length, and f'' the distance of the image from the surface. The derivation of this formula is shown in Fig. 35.

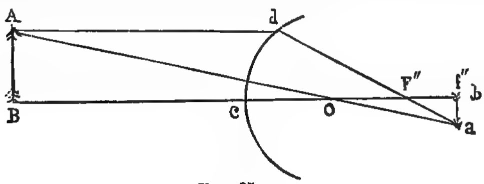

FIG. 35.

For if we draw in this figure the ray $A\,d$ from the point A parallel to the axis, it is refracted as if it were a ray coming from some point in the axis at an infinite distance, that is to say, it is deflected to F'' the posterior focus, and proceeds beyond F'' until it meets the other rays coming from A in the point of focal reunion a. Thereby are formed the two similar triangles $d\,c\,F''$ and $a\,b\,F''$. Hence,

$$a\,b : d\,c = f''\,F'' : c\,F''$$

Since the line $A\,d$ has been drawn parallel to $B\,c$, the side $d\,c$ is equal in size to the object $A\,B$. If we substitute the term F'' for the line $c\,F''$, and the term $f''-F''$ for the line $f''F''$ according to our premises we get the equation

$$a\,b : A\,B = f'' - F'' : F''$$

12. *Virtual Images.*—When the object is nearer to the refracting surface than the principal anterior focus, there is no real image, but only a virtual image is formed on the same side of the surface as the object is itself. In this case f'' is hence negative, otherwise the same formulæ apply as above. Since the rays of direction do not cross, this virtual image is erect, and since it is always farther from the optic centre than the object, it is larger than the object. The amplification of the image diminishes as the object approaches the refracting surface, for when the object has just passed through the anterior focus the image is at an infinitely great distance, and is therefore infinitely enlarged, while when the object touches the refracting surface, object and image coincide in position and size. The formation of virtual images is shown in Fig. 36.

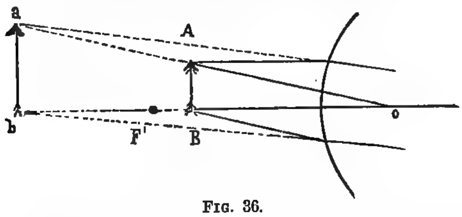

FIG. 36.

13. All the facts above stated with reference to images formed in the denser medium of objects situated in front of the refracting surface, are equally true conversely of images formed in the rarer medium of objects situated behind the refracting surface.

14. *Refraction by Concave Surfaces.*—When the refracting surface is concave on the side of the rarer medium, rays coming from any one point are not reunited in an actual focus. But if the direction which they assume after their refraction be prolonged backward, the prolonged rays will meet in a point representing the focus. This focal length is therefore always negative, that is to say, the focus is always on the same side of the surface as the object itself. The position of the principal foci or any conjugate point of focal reunion can be found by the same formulæ as in the case of a convex surface, but these values are always negative, because the radius of curvature of the concave surface is negative in direction. The images formed by a concave refracting surface are hence always on the same side as the object, that is to say, they are not real, but virtual, and can only be smaller than the object, as is shown in Fig. 37.

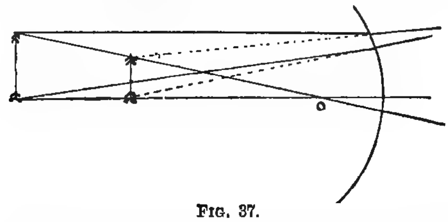

FIG. 37.

15. *Refraction by Successive Surfaces.*—When light passes through a number of surfaces of different media, the above developed formulæ apply to the refraction through each surface. Thus the focus of the first surface forms the luminous point for the second refraction, its distance being counted positive when it is in front of the second surface, and negative when it happens to be behind that surface. Similarly the image formed by the second surface is the object for the third surface, and so on. But such calculations become very cumbersome if we try to follow actually the course of the rays through their successive refractions. The matter is simplified by treating the series of surfaces as one system having certain fixed points, the position of which determines the path of all rays. These are called the cardinal points. Their position remains constant in any given system, and can be calculated, if the refractive indices of the media, the radii of curvature of all the surfaces, and the distances of all the surfaces from each other are known, provided the centres of curvature of all the surfaces lie in a straight line, the axis of the system. If the latter condition is fulfilled, the system is said to be centred. The cardinal points are the two foci, the two principal points, the two nodal points.

16. *The Foci.*—The foci, anterior or first, and posterior or second, are the two points—one on either side of the system—at such distances that rays coming from the focus are rendered parallel to each other by their last refraction. Conversely parallel rays, entering the system from either side, are united in a point in the focus on the other side, as has been shown to occur in the case of a single refracting surface. The distance of either one of the foci of a compound system from the surface next to it may be computed in the following manner: Let n be the refractive index of the first medium, n_1 of the second, n_2 of the third, and so on. Let S_1 be the first refracting surface, and r_1 its radius of curvature; S_2 the second surface, and r_2 its radius, and so on. The value of r is positive if the surface is convex on the side of the luminous point; negative if it is concave. Let d_1 be the distance from the first surface to the second, d_2 from the second to the third, and so on. Determine the foci of each surface by itself, without reference to the other surfaces. According to formulæ (2) and (2a), we get for the first surface,

$$F_1' = \frac{n\,r_1}{n_1 - n} \text{ and } F_1'' = \frac{n_1\,r_1}{n_1 - n}$$

and for the second surface,

$$F_2' = \frac{n_1\,r_2}{n_2 - n_1} \text{ and } F_2'' = \frac{n_2\,r_2}{n_2 - n_1}$$

The posterior focus for the first and second surfaces taken together will now be found by considering F_1'' as the luminous point for S_2; and, on applying the formula (3), viz., $f'' = \dfrac{F''\,f'}{f' - F'}$, we get the equation

$$F_{(1+2)}'' = \frac{F_2''\,(d' - F_1'')}{(d' - F_1'') - F_2'} \tag{5}$$

which states the distance of the posterior focus of the system of surfaces S_1 and S_2 from S_2. The distance of the anterior focus of S_1 and S_2 together, from S_1, is similarly found by the application of formula (3*a*), viz., $f' = \frac{F''f''}{f'-F''}$ and following the light in the reverse direction, hence

$$F_{(1+2)}' = \frac{F_1'(d_1 - F_2')}{(d_1 - F_2') - F_1''} \qquad \text{(5a)}$$

By treating the surfaces S_1 and S_2 as one system, we can then proceed to determine the foci for $S_{(1+2)}$ and S_3, and so on.

The foci of an optic system having been determined, the focal length is now measured by the distance of each focus from its corresponding principal point. If we call the anterior or first principal point H', and the posterior or second principal point H'', then $F'H'$ is the anterior focal length, and $H''F''$ is the posterior focal length.

17. *The Principal Points.*—The principal points are the two points where the axis of the system is cut by the two principal planes. The significance of the principal planes can be best explained on comparing the refraction by a single surface with the course of rays through a compound system. In the case of the single surface *a b*,

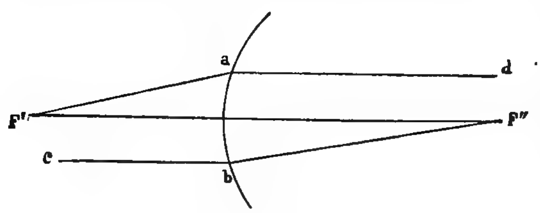

FIG. 38.

Fig. 38, the ray F' *a*, coming from the anterior focus, is, by its refraction, made parallel to the axial ray F' F''. Incident and refracted rays intersect here in the plane of the refracting surface. The same is true of the ray F'' *b* coming from the posterior focus, and its continuation, *b c*, after refraction. In Fig. 39, however, where there are two refracting surfaces, *a b* and *a' b'*, the ray, F' *a*, coming from the anterior focus, is twice bent from its course, viz., at each surface, so as to finally assume the direction *a' d*, parallel to the axial ray. In this case the incident ray, F' *a*, and the refracted ray, *a' d*, do not

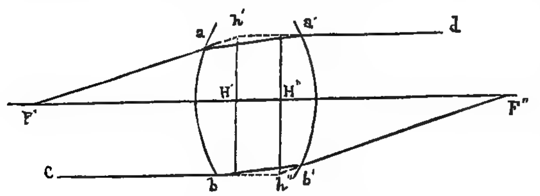

FIG. 39.

intersect, being separated by the space between *a* and *a'*; but if we prolong them through this space, their prolongations intersect at the point *h'*. A plane, *h'* H', laid through this point, vertical to the axis, is the first principal plane. Similarly, if we prolong the ray F'' *b'*, which proceeds from the posterior focus to the surface *a' b'*, it will cut the backward prolongation of the refracted ray *b c* at the point *h''*, which point determines the position of the second principal plane. It is evident, from Fig. 39, that the ray which before entering the system is directed toward the point *h'* in the first principal plane, has a direction after its last refraction as if it came from a point in the second principal plane at the same distance from the axis as the point *h'*. Likewise the ray which proceeds in the opposite direction from F'' toward the point *h''* has a direction, after its last refraction, as if it came from a point in the first principal plane at the same distance from the axis as the point *h''*. This mutual relation of the two principal planes is the same for all rays, not merely those coming from F' or F''; and it is true also for any distance at which the points *h'* and *h''* may be from the axis within the limitations of Section 4. In other words, any ray which is directed toward a given point in the principal plane, on the side from which it comes, apparently emerges from the other principal plane at the same distance from the axis. We can thus determine by construction the direction of any ray after its refraction through a compound system, and thereby find the place of the image formed by such rays, if we know the position of the foci and the two principal planes. In Fig. 40, let

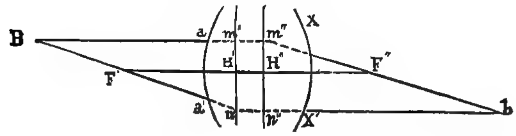

FIG. 40.

a a' be the first, and *x x'* be the last refracting surface of a compound system; let H' be the first, and H'' be the second principal point, F' the anterior, and F'' the posterior focus. Draw the axis F' F''. From the point *B* there proceeds the ray *B a*, parallel to the axis, and verging toward the point *m'* in the first principal plane. Hence, after its last refraction, that ray has a direction as if it came from the point *m''* in the second principal plane, going through the posterior focus F''. Another ray convenient to follow is the one coming from *B* and passing through F'. This verges toward the point *n'* in the first principal plane. Hence, by its refraction, it is turned in the direction *n'' b*, as if coming from *n''* and proceeding parallel to the axis. Where the two refracted rays meet, at the point *b*, is the image of the luminous point *B*.

Since the course of rays is determined by their relation to these imaginary principal planes, the focal lengths of a system must be measured by the distance of each focus from its corresponding principal point, and not by the distance of the foci from the refracting surfaces. Indeed, for all subsequent purposes, we can practically ignore the position of the refracting surfaces of any system, after we have once determined the position of the foci and of the principal planes. For now all the problems relative to the position of object and image can be solved by the same formulæ as in the case of a single refracting surface, by measuring the focal lengths from the principal planes.

18. The position of the two principal points is determined by the position of the two planes in which the images of a certain other plane are of equal size and direction. In every refracting system there exist only two such planes, and these are the principal planes; and there exists, moreover, only one plane of which two images of equal size and direction are possible. Hence, in order to find the principal points, we must determine where a line must be in order to form two images of the

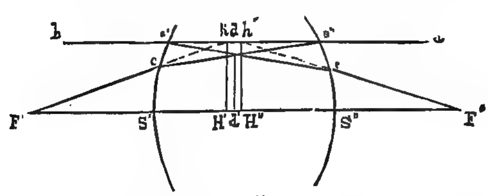

FIG. 41.

same size and direction, and then learn the place of these two images.

This proposition can be demonstrated by means of Fig. 41, in which we have a refracting system bounded by the surfaces *s'* S' and *s''* S''. F' is the first and F'' the second focus. Draw the ray F' *c*, which is deflected toward *s''* by the surface *s'* S', and is made parallel to the axis by the surface *s''* S''. By the intersection of the prolonged incident and refracted rays the point *h'* determines the

position of the first principal plane. Similarly a reverse ray going from F''' to e is bent twice, so as to follow ultimately the direction $s' b$ parallel to the axis. The prolongations of the ray before entering and after leaving the system give us the point h'', and thereby the position of the second principal plane. If we draw a line $d\ d'$ vertical to the axis from the point d, where the rays coming from each side intersect after their first refraction, the virtual image of $d\ d'$ produced by the surface $s'\ S'$ coincides with the first principal plane $h'\ H'$, while the image formed by the surface $s''\ S''$ coincides with the second principal plane $h''\ H''$, as is evident from the refraction of the rays according to the construction; and these two images are alike in size. The distance of d' from each surface is determined by the equation (4a).

$$a\ b\ (image)\ :\ A\ B\ (object) = f'' - F''\ :\ F''$$

or more conveniently on account of the erect position of the virtual image,

$$a\ b\ :\ A\ B = F'' - f''\ :\ F''$$

Each surface is here considered independently of the other. Hence it can be deduced that the distances of d' from each surface must be to each other as the focal lengths of the surfaces, in order to have the images formed by the two surfaces of equal size. This is shown in Fig.

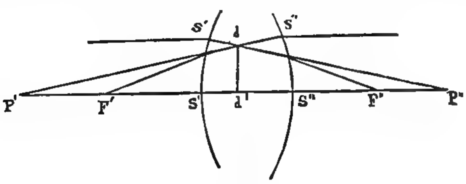

FIG. 42.

42, where $P'\ S''$ is the focal length of the surface $s''\ S''$ in the medium between the two surfaces and $P''\ S'$ of the surface $s'\ S'$.

A consideration of the two triangles $P'\ S''\ s''$ and $P''\ S'\ s'$ and their segmentation by the line $d\ d'$ proves that

$$d'\ S'\ .\ d'\ S'' = P''\ S'\ :\ P'\ S'' \qquad (6)$$

Hence, in order to find the principal planes of a system, determine the position of a point in the axis, the distances of which from the two refracting surfaces are to each other as the focal lengths of these surfaces in the medium between them. Then calculate the place of the images of this point formed by each surface independently of the other, according to formula (3).

When the optic system consists of more than two refracting surfaces, determine the principal points for two adjoining surfaces, and then divide the distance between the one principal point next to the third surface and the third surface into two parts, which are to each other as the corresponding focal lengths in the intervening medium. The images of the dividing point formed independently by the third surface, and by the system of the other two surfaces are then the principal points of the system of three surfaces.

19. *The Nodal Points.*—The nodal points of a compound system replace the optic centre of a single refracting surface. For while all rays of direction pass undeflected through the optic centre of a single surface, a second surface will deflect all rays with the exception only of the axial ray. Hence a single optic centre cannot exist in a compound system. But there exist two points in the axis, viz., the nodal points, of such properties that a ray directed toward the first before entering the system pursues a course after its final refraction as if it had passed through the second nodal point parallel to its original direction.

That a pair of points of such properties must exist in any compound system is evident from Fig. 43, where F' is the first and F'' the second focus, and $m'\ H'\ n'$ the first and $m''\ H''\ n''$ the second principal plane. A ray $B\ m'$, coming from the luminous points B, forms with the refracted ray $m''\ b$ any angle of less than 180° as seen from below, while the ray $B\ n'$ forms with its refracted prolongation $n''\ b$ an angle greater than 180° as seen from below. Somewhere between m' and n' there must be a

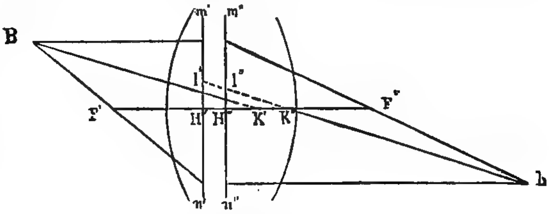

FIG. 43.

level where the incident ray includes with its continuation beyond the second principal plane an angle of 180° exactly, in other words, where the two are parallel. Let this be at the level l'. If we prolong the incident ray $B\ l'$, the points where this prolonged ray and the refracted ray $l''\ b$ cut the axis, viz., K' and K'' answer the requirements of the nodal points. The position of the nodal points relative to the principal points is made evident in Fig. 44.

In this figure we will draw the line $B\ F'$ on F' vertical to the axis. From the point B there proceeds a ray of direction $B\ K'$ to the first nodal point K'. According to our premises the ray $K''\ b$ must be parallel to $B\ K'$ and in the direction $K''\ b$ lies the image of B, at an infinite distance from the optic system. Since the point B lies in the anterior focal plane, every ray proceeding from it is rendered parallel by its refraction to the ray of direction coming from B. Hence the ray $B\ h'$ parallel to the axis is continued after passing through the second principal

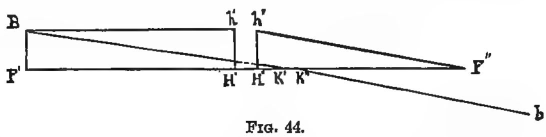

FIG. 44.

pal plane, as $h''\ F''$ parallel to $K''\ b$, and hence also to $B\ K'$. From the similarity of the triangle $B\ F'\ K'$ and $h''\ H''\ F''$ it is evident that the distance

$$F'\ K' = H''\ F'' \qquad (7)$$

and by reversing the figure and constructing the course of rays coming from the posterior focal plane, we can similarly learn that the distance

$$F''\ K'' = H'\ F' \qquad (7a)$$

and that hence

$$H'\ H'' = K'\ K'' \qquad (7b)$$

which latter corollary is also apparent from Fig. 43. The position of the nodal points can hence be at once learned by formulæ (7) and (7a), after knowing the position of the principal points and of the foci. And thus we have all data necessary to follow the course of rays through any compound optic system.

20. *Lenses.*—It will be best to refer briefly to the optic properties of glass lenses before we proceed to the eye itself. According to the curvature of their surfaces and the distance between them, lenses either reunite into one point all the rays coming from one point, or disperse them. The former, or collecting lenses, have a positive focal length. They form inverted actual images of distant objects, and erect, virtual, and enlarged images of objects nearer than their focus. The latter, or diverging lenses, have a negative focal length, and can form only erect, virtual images, smaller than their object. When both surfaces of a lens are convex, or one is convex and the other plane, the lens belongs to the former variety; when one surface is concave and the other plane, or when both are concave, we have a diverging lens with negative focus. When one surface is convex and the other concave, the positive or negative value of the resulting focal length depends not only on the curvature of the two surfaces, but also on the distance between them.

Accommodation.

The refractive index of the glass used for spectacles is so near 1.5 that we can calculate on that basis without important error, at least for spectacles. Taking this index we find that in a plano-concave, or plano-convex lens, the focal length is twice the length of the radius of the curved surface, measuring from the curved surface, according to formula (2) or (2a). The first and second focal lengths are of course equal to each other, when the lens is surrounded by the same medium on both sides, according to (2b). The distance of the foci from the plane surface is, however, not the same as from the curved surface, for the focal lengths are measured from the principal points, one of which coincides with the curved surface, while the other is between the two surfaces. But for most of our purposes we can ignore the thickness of the glass lenses, as long as this is slight compared with the other dimensions, and practically measure the focal length from the surface, or, indifferently, from the centre of the lens. If, hence, we express the focal length of a plano-convex lens as

$$F' = F'' = 2\,r$$

we get for a bi-convex lens the formula

$$F = \frac{r' + r_2}{2}$$

If the radii of curvature of the two surfaces are alike, we find the focal length equal to the radius, provided the index of refraction is practically 1.5. This applies similarly to biconcave lenses, F being, however, negative. In lenses with one convex and one concave surface, the measurement of the focal length is not quite so simple, because the thickness of such a lens cannot be ignored without error, and the principal points can in such a combination be outside of the substance of the lens.

The so-called strength of lenses is measured differently, according to the unit which we adopt. Formerly a lens of the focal length of one inch—either negative or positive—was taken as the standard and called 1. Any lens of longer focal distance could only be named in fractions, $\frac{1}{2}$, being one-half of that strength; that is to say, having a focal distance of two inches, and $\frac{1}{12}$ having twelve inches focal length, while a stronger lens, greater than 1, had a corresponding shorter focal distance. Since the adoption of the metric system in ophthalmology, the opposite way of enumeration has been employed. A lens of the focal length of one metre is now taken as unit, and called one dioptric, or 1 D. Any lens of longer focal length is expressed in a decimal fraction, thus, 0.25 D, means a lens of 4 metres focal length. The stronger lenses, on the other hand, are measured by several dioptrics; thus, 10 D, being a lens of $\frac{1}{10}$ metre, or 10 centimetres focal length. Since both systems of measurement are yet in use, it is best to become familiar with both. As regards the convenience in calculation, for which purpose the dioptric system was introduced, there is really not much difference between them. In order to convert the number of a lens from one system into another, it is to be remembered that the metre is equal to 39.37 English inches, or 36.94 French inches. On account of inaccuracies in grinding glasses, the whole number, 40 (English), and 36 (French), are close enough for practical purposes. Hence, to get the dioptric equivalent of an English number, divide that number into 40, and to translate a certain number of dioptrics into the French inch system, divide the number into 36.

21. In order to examine the refraction in the eye we must determine the refractive indices of the different media, the curvature of the surfaces, and the distances between the separate surfaces.

22. *Refractive Indices of the Media of the Eye.*—The refractive indices have been measured by various observers in dead eyes by means of different physical methods. On account of less perfect methods former results must be taken with some caution. Even the more recent determinations made with Abbe's refractometer have yielded not inconsiderable discrepancies amongst different observers, which may perhaps be attributed to individual variations. The following table of refractive indices is copied from Zehender and Matthieson.[1] It is the most complete of all recent determinations.

Subject.	Cornea.	Aqueous humor.	Ant. capsule of lens.	Lens. Cortical layer.	Lens. Middle layer	Lens. Nucleus.	Post. capsule of lens.	Vitreous body.	Distilled water.
Male, 50 years, I....	..	..	..	1.3953	1.4087	1.4121	1 3455	..	..
II....	1.3770	..	..	1.3853	1.4067	..	1.3658	1.3348	..
Female, 45 years, I..	..	..	..	..	1.4044	1.4112	..	..	..
II..	..	..	..	..	1.4044	1.4094	..	..	..
Female, 26 years, I..	..	..	1.3600	1.3867	1.4056	1.4154	..	..	..
Male, I.............	1.3772	..	..	1.3902	1.4062	1.4077	..	1.3342	..
Unknown, I.........	..	..	..	..	1.4076	1.4091	..	..	..
II.........	..	..	..	..	..	1.4096	..	..	..
Female, 45 years, I..	..	..	..	1.3930	1.4018	1.4101	..	..	..
II..	..	..	..	1.3811	1.4073	1.4107	..	..	..
Child of two days, I.	1.3721	1.3338	1.3821	..	..	..	1.3503	1.3340	..
II.	..	..	1.3780	..	..	..	1.3572	..	..
Average	1.3754	1.3338	1.3734	1.3886	1.4059	1.4106	1.3547	1.3348	1.3326

The indices of cornea, aqueous humor, and vitreous body are so nearly alike that an average index of the three can be used as a basis for calculation without appreciable error. Helmholtz assumes 1.3365 as the most nearly correct average in his latest publication. While the index of the capsule of the lens is considerably above this figure, this membrane is so thin and its surfaces so nearly parallel to each other that its influence on the rays can be neglected without error. The index of the lens itself increases from the external layer to the nucleus, so that the lens really consists of a large number of layers of increasing optic density. By reason of this stratified arrangement the total refractive power of the lens is greater than it would be were the entire lens of the refractive index of its nucleus. For each layer, as we proceed toward the nucleus, increases not only in refractive index but also in convexity. This is evident when we compare the following two lenses, the thickness of which must not be more than a small fraction of the focal length. Let one of these lenses, A, be homogeneous and have the refractive index n'', the index of the surrounding medium being n, while the other lens, B, has only a core or nucleus more convex than the surface of the lens of the index n'', the superficial layer having an index n', intermediate between n and n''. If n' is now very nearly equal to n, we have practically a lens of the same index as that of the lens A, but of shorter radius of curvature, and hence of shorter focal length. If n', however, is very nearly equal to n'', the lens B will be practically of the same strength as the lens A, but never less. Hence, no matter in what ratio the index increases as we proceed toward the nucleus, the lens gains thereby in strength. The special advantages of this stratification over a homogeneous lens is the more regular refraction of rays very oblique to the axis, as has been shown mathematically by Hermann.[2] Thereby the images of objects situated laterally from the axis of the eye are not distorted as they would be when projected by a glass lens. The actual refraction of the excised human lens was found by Helmholtz in two measurements to be equal to that of a homogeneous lens of the same curvature, but with a refractive index = 1.4519 and 1.4414. But in his latest estimate (1874) he adopts 1.4371 as the more nearly correct average total refractive index of the lens in its normal attachment during life.

23. *Curvature of the Ocular Surfaces.*—The curvature of the surfaces cannot be measured with accuracy in the dead eye, on account of the altered tension of the eyeball. In the living eye the curvature can be calculated from a measurement of the size of images reflected from the surfaces. The cornea, for instance, acts as a polished convex mirror, producing diminutive images, apparently behind its surface. The size of such an image is to half the radius of curvature of the mirror as the size of the object is to the distance of the object from the cornea. The size of the image is most conveniently measured by means of Helmholtz's ophthalmometer. This consists of a telescope, in front of which there is a thick plate of glass with parallel surfaces, which has been cut in two,

so that the line, separating its two halves, exactly bisects the field of the telescope. The two plates can be turned on an axis vertical to the line of separation. As long as the two plates are practically one, that is to say, lie in one and the same plane, objects are seen through them in their natural shape; but when the two plates are turned in opposite directions, the objects appear split into two halves, which are displaced laterally in opposite directions, in proportion to the rotation of the plates. The explanation of this displacement has been given in Section 3. For actual use the ophthalmometer is directed toward the observed eye, at a distance of several metres, and the images of two lights, one placed on either side of the telescope, or, rather, the ideal line uniting the two lights, are observed as reflected from the cornea. The two lights are, of course, placed in the prolongation of the line separating the two glass plates of the instrument. These plates are then turned by a screw until the image is doubled; that is to say, until the two halves are displaced laterally through the open space occupied by the image. From the observed degree of rotation, and the thickness of the plates, the extent of displacement, and hence the size of the image, can be calculated, and thereby the radius of curvature of the cornea be determined.

The radius of curvature, measured by reflection from the middle portion of the cornea, has been found to vary in different eyes from 7 to 8.2 mm., an average near 7.8 mm. being the most common. No definite relation has been found between this radius and any existing ametropia. On observing the reflection from the marginal portion of the cornea, it can be seen, even with the unaided eye, that the images are larger than in the centre; that is to say, that the convexity of the cornea diminishes from the centre toward the periphery. The cornea is therefore not a segment of a sphere, but of an ellipse, the major and minor axis of which are to each other in the ratio of about 9 to 10 or 11. The posterior surface of the cornea is found in the dead eye to be nearly concentric with the anterior surface. This fact, in connection with the rather slight difference in the indices of cornea and aqueous humor, allows us to consider the cornea, aqueous humor, and vitreous body as one optically homogeneous medium, bounded by a single surface.

The radius of curvature of the anterior surface of the lens has been found to vary between 9 and 12, and, exceptionally, even 14 mm.; and that of the posterior surface between 5.5 and 6.5 mm. The images reflected from these surfaces are so faint, on account of the small difference in the refractive indices of aqueous humor and lens, that the ophthalmometer can be used to advantage only with sunlight. The apparent size of these images requires a correction, for the cornea and aqueous humor act as a magnifying lens, interposed both in the path of the rays from the object to the reflecting surface, and, again, between the latter and the ophthalmometer. In the case of the images reflected from the posterior surface of the lens, the substance of the lens must also be taken into account as part of the magnifying system. It is necessary hence to know the distance from the cornea to the anterior surface, and from the latter to the posterior surface of the lens, in order to calculate the radii of curvature. The posterior surface of the lens acts as a concave mirror, giving an inverted and very small image.

24. *Distances between the Refracting Surfaces.*—The distance of the anterior surface of the lens from the cornea has been determined according to various methods by Helmholtz and his pupils. By means of a focussing microscope with graduated screw, or by means of the ophthalmometer with the aid of movable lights, it was learned how far the rim of the iris appears behind the cornea, and the true position of the pupil was then calculated from the known refractive power of cornea and aqueous humor. Values between 3.2 and 4 mm. have been found in different eyes. Helmholtz adopted 3.6 mm. as a sufficiently accurate average to use in his diagrammatic eye. The distance of the posterior surface of the lens from the cornea can be measured only by complicated methods, based on the observation of the parallax between the reflection from the cornea and that from the posterior surface of the lens, and by taking into account the influence of cornea, aqueous humor, and lens-substance on the rays. It has been found to approximate very closely to 7.2 mm., which gives 3.6 mm. as the average thickness of the lens (while the eye is not accommodating). The lens taken out of the eye increases in thickness on account of elastic retraction, as will be explained in the article on accommodation.

25. *Diagrammatic Eye.*—We learn thus that there are noticeable differences in the optic constants of normal eyes, so that two eyes, both emmetropic, are not necessarily identical in construction. But within the latitude of emmetropic eyes the deviations of the different figures from the average counterbalance each other, so that the object, the formation of sharp images of distant objects in the plane of the retina, is equally attained in all. From numerous measurements made by himself and others, Helmholtz has constructed the following diagrammatic eye, corresponding to the average figures of human emmetropic eyes:

	Millimetres.
Refractive index of cornea, aqueous, and vitreous humor	1.3365
Refractive index of the lens as a whole	1.4371
Radius of curvature of the cornea	7.829
Radius of curvature of the anterior surface of the lens	10.
Radius of curvature of the posterior surface of the lens	6.
Distance from the anterior surface of the cornea to the lens	3.6
Thickness of the lens	3.6

From these data are computed:

Anterior focal length of the cornea, aqueous and vitreous humor,	23.266
Posterior focal length of the cornea, aqueous and vitreous humor,	31.095
Focal length of the lens (in place)	50.671
Distance of first principal point of the lens from its anterior surface	2.12
Distance of second principal point of the lens from its posterior surface	1.274
Distance of the first principal point H' of the entire eye behind the cornea	1.750
Distance of the second principal point H'' of the entire eye behind the cornea	2.117
Distance of the first nodal point K' of the entire eye behind the cornea	6.968
Distance of the second nodal point K'' of the entire eye behind the cornea	7.321
Anterior focal length of the entire eye	15.507
Posterior focal length of the entire eye	20.719

This latter figure plus the distance of H'' from the cornea gives us 22.834 mm. as the optic axis from the anterior surface of the cornea to the sensitive plane of the retina, and adding to this number the thickness of the sclerotic coat, viz., 1.3 mm., we obtain about 24.1 mm. as the length

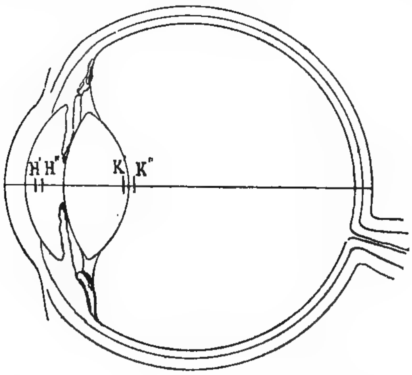

FIG. 45.

of the eyeball. Anatomical measurement has shown the eyeball to vary between 22.5 and 27 mm. in length, 24 to 24.6 mm. being the most common limits. Unfortunately these anatomical measurements refer mostly to eyes the refractive state of which was not determined during life. The diagrammatic eye of Helmholtz and the position of its cardinal points is illustrated by Fig. 45, amplified twice.

26. In the calculation of the size of retinal images and of the influence of glasses on sight, in fact, in almost all the problems not relating to the changes during accom-

modation, we can arrive at results sufficiently accurate by taking as a basis the simplified diagrammatic eye of Donders, in which the lens is omitted. It consists of a single refracting surface, representing the cornea with a radius of curvature of 5 mm. The single internal medium, optically identical with the cornea, has a refractive index of 1.333 ($\frac{4}{3}$). Thereby we deal with but one principal point, viz., in the plane of the cornea, and but one nodal point, the centre of curvature of the cornea. The first focal length is 15 mm., the second 20 mm., which latter figure represents likewise the length of this eye.

The human eye has some advantages not possessed by artificial optic instruments, but also various faults which a skilful optician can avoid.

27. *Visual Field.*—There exists no instrument which has as extensive a field as the eye, since images are depicted on the retina of objects situated as far as 55 to 65 degrees from the line of direct sight, and on the temporal side even as far as 90 to 100 degrees. The fact that images formed near the periphery of the retina are not seen distinctly, is due principally to the relative dulness of sensibility of the peripheral portion of the retina. The images themselves are quite sharp, as we can learn by examining the periphery of the retina in the eye of another person with the ophthalmoscope. When the refraction is emmetropic in the centre of the retina, it is very nearly so also in the extreme periphery. This is due to the elliptical curvature of the rear of the eyeball and of the retina (compare Section 9). Moreover, the elliptical curvature of the cornea, and still more the stratified structure of the lens prevent the distortion of images, which ordinary spherical, homogeneous lenses would produce in the case of objects situated far laterally from the axis of the system.

28. *Spherical Aberration.*—Spherical lenses do not collect in the common focus those rays which are very oblique to the axis or strike the refracting surface far from its centre. This spherical aberration is shown in Fig. 29. In the eye it is almost wholly obviated by the elliptical shape of the cornea and the stratification of the lens. The iris, moreover, serves the purpose of a diaphragm, so that the extreme marginal rays cannot ordinarily pass through the pupil.

29. *Chromatic Aberration.*—The chromatic aberration of lenses gives rise to colored rings around images otherwise well defined. It is due to the fact that the index of refraction is not the same for waves of light of different length. Hence there is necessarily a slight separation of the different colors when mixed or so-called white light is refracted by a lens. The eye is not free from this defect; it possesses it to about the same extent as if it consisted of water. If either end of a sharply defined spectrum be observed through an achromatic telescope, the other end appears diffuse until the adjustment of the telescope (or of the eye) is altered. The difference in adjustment corresponds to about 1.5 to 2 dioptrics; that is to say, an eye forming a sharp image of an object emitting violet light, requires an additional convex lens of some 75 to 50 centimetres focal length, in order to bring the less refrangible red rays into a focus upon the retina. Ordinarily we are not conscious of this defect, because the eye is adjusted for the middle and brightest portion of the spectrum, viz., yellow and green to blue, while the red and violet rays form circles of diffusion around the image, which blend, and thereby diminish in distinctness of color, being, moreover, much less bright than the sharply defined image which they surround. But we can see these colored circles of diffusion quite distinctly on looking at some bright object, while covering one-half of the pupillary aperture with an opaque screen, for by thus cutting off half of the pencil of light, we prevent the blending of the color-rings, and the object shows then a blue edge on one side and a yellow margin on the other. The chromatic aberration is also quite noticeable on observing a luminous point through a violet glass, which absorbs the middle part of the spectrum, whereupon we see either a red point surrounded by a blue halo, or a red margin around a blue point of light, according to the refractive state of the eye.

30. *Imperfect Centring.*—The optic system of the eye is not perfectly centred. The centre of the cornea coincides, indeed, with the vertex of its ellipse; but the major axis of this ellipse forms an angle with the visual line, or line of direct sight; that is to say, the line of the ray of direction passing from an observed point through the nodal points to the centre of the retina. The visual line deviates toward the nasal side of the corneal axis (proceeding outward) to an extent of 4 to 8 degrees. This relatively oblique direction of the corneal axis, when extreme, may give some eyes a false appearance of divergent squint. Still no noticeable deficiency of sight can be attributed to this want of centring.

31. *Astigmatism.*—More serious defects are those due to irregularities in the curvature of the refracting surfaces. We have so far considered only the refraction of rays which lie in one plane, with the tacit assumption that our refracting surfaces are the surfaces of true bodies of rotation, that is to say, that the radii of curvature are equal in all meridians. For, in this case, any of the figures illustrating the course of rays in the plane of the paper, may be supposed rotating on their axis in order to illustrate the course of rays in all planes. But this assumption is scarcely ever correct in the case of the human eye. On measuring with the ophthalmometer the corneal radius of curvature in the horizontal, and then in the vertical meridian, the two radii are found to differ from each other to a trifling extent even in the most normal eyes. More commonly, but not always, the radius is smallest in the vertical direction. The two meridians presenting the greatest discrepancies are not necessarily horizontal and vertical; they may have any inclination. A difference of 0.1 mm. between the radii of two meridians at right angles to each other, separates the focus of one meridian from that of the other to the extent of about 0.3 mm. Differences of 0.01 to 0.05 mm. in the radii are the most common. The cornea is hence the segment of an ellipsoid with three unequal axes. As a result, the focal length is not the same in any two meridians of unequal curvature, and hence the points of an object cannot be represented by points in the images formed in such an

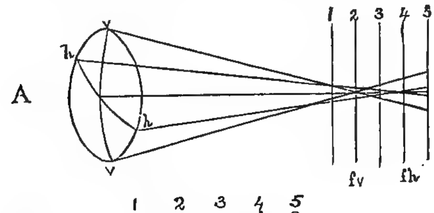

FIG. 46.

eye. If in Fig. 46, *A*, we represent the ellipsoid cornea with the horizontal meridian *h h* having a greater radius of curvature than the vertical meridian *v v*, the focus in the former meridian *f h* must be further off than *f v*, the focus of the vertical meridian. If we place a screen successively in the positions numbered 1, 2, 3, 4, and 5, the image of a distant point would appear as shown in an exaggerated manner in Fig. 46, *B*, 1, 2, 3, 4, and 5. The refraction by such an ellipsoid cornea can be imitated by means of an ordinary spherical lens, to which is added a cylindrical lens, the segment of a cylinder, thereby introducing a difference in the refractive strength in the two meridians, of which one is parallel with, and the other at right angles to, the axis of the cylinder. This defect of the eye is known as the regular astigmatism (from α, privative, and στίγμα, a point). There are very few, if any, eyes entirely free from it. When the inequality in the refraction of two meridians exceeds the strength of about one-half to one dioptric, it may necessitate correction by means of cylindrical glasses (see under Astigmatism). As the result of regular astigmatism, lines of different inclination are not seen equally distinctly. If, for instance, the eye be accurately emmetropic in the horizontal meridian, while the greater curvature of the vertical radius brings the

focus behind the retina in the latter meridian, then only horizontal lines at infinite distance will be sharply defined on the retina, while the more a line approaches the vertical direction, the more diffuse will be its retinal image. The interference with sharp sight increases, of course, with the degree of astigmatism. A discrepancy between two meridians amounting to less than half a dioptric does not interfere with sight to any practical extent.

Irregular Astigmatism gives rise to such slight imperfections of retinal images as the radiation of "rays" around stars and other small luminous points. It is due to optic inequalities in the different sectors of the lens, whereby some of the rays are deflected from the path which they would pursue in a perfect eye. This irregular astigmatism does not exist after the lens has been removed.

32. *Muscæ Volitantes.*—Few, if any, eyes do not at times see flying specks, so-called muscæ volitantes. They appear in the form of transparent rows of beads or groups of granules, or simply shadowy streaks floating about when the eye is moved. They are due to the presence of similarly shaped objects floating in the vitreous body, cells and groups of cells, and shreds of membranes, transparent, but of an index of refraction slightly different from that of the medium surrounding them. Their rims hence cast shadows similar to those of a glass ball between a light and a screen. These shadows are most marked when the rays of light are parallel in the vitreous body, when the source of light is in the anterior focus of the eye. We can observe them well by using as source of light a pinhole in an opaque screen held close to the eye and toward the sky, or on looking into a microscope. When the attention has once been called to them they may continue to annoy nervous persons, mentally rather than optically. These shadows, even if inconvenient, are not indicative of any disease.

33. *Ametropia.*—The last and most important imperfection of the eye is the not uncommon want of harmony between the focal length and the anatomical length of the eyeball, the refractive defect known as ametropia. We have seen that the radii of curvature, the distance from cornea to lens, the length of the eyeball, and perhaps even the refractive indices, may vary within certain limits in different eyes. It is only in the more fortunate instances that the ideal result, viz.: the coincidence of the posterior focal plane with the position of the retina, is obtained, while in many eyes, otherwise healthy, the images of distant objects are formed, either in front of the retina, constituting myopia, or behind the retina, the condition of hypermetropia. In either of these two cases the retinal images of distant objects are blurred in proportion to the distance of the retina from the focal plane, and in proportion to the size of the pupil. The lower degrees of ametropia may be due to an unproportional curvature of the corneal and lenticular surfaces, while the length of the eyeball is normal; but when the anomalies of refraction reach any high degree, the eyeball is found, not merely relatively, but absolutely too long in myopia, too short in hypermetropia.

While emmetropia is the most fortunate refractive condition, it is not necessarily the most common. Statistics show that in the upper classes of schools, and especially high schools, in European countries, from one-third to one-half, and sometimes even two-thirds of the eyes are near-sighted, and some five to ten per cent. are far-sighted. In this country the figures are a little more favorable, as regards the frequency of emmetropia. Fuller details of these statistics will be given under the heading Myopia.

34. *Refraction during the Growth of the Eye.*—In the infantile eye all the dimensions are, of course, smaller than in the adult organ. The shorter axis of the eyeball is, however, proportionate to the shorter radii of curvature of cornea and lens, so that emmetropia can exist. Indeed, during childhood there are more emmetropic eyes than in adult life. The eyes of babes, however, are most frequently far-sighted, as shown by ophthalmoscopic examination. Jaeger formerly asserted the contrary, having found 78 eyes myopic out of 100, and but 5 accurately emmetropic in new-born babes. He seems to have been misled however, by the accommodated condition of the infantile eye, for later observers, who paralyzed the accommodation by means of atropia, have arrived at different results. Thus Eli[3] found but 11 eyes myopic, 17 emmetropic, and 72 hypermetropic in 100 eyes of infants. Bjerrum[4] noted 61 hypermetropes, 23 emmetropes, and 3 myopes on examining 87 babes. Horstmann[5] found in 50 new-born infants 88 far-sighted eyes, 10 emmetropic, and but 2 short-sighted eyes. In 50 children, of the age of one to two years, 84 eyes were far-sighted, 10 normal, and 6 short-sighted; while in 50 children, four to five years old, hypermetropia had diminished, involving 74 eyes; myopia had increased to 13 eyes; 13 eyes being emmetropic. These figures show that the refraction increases ordinarily as the child advances in years. During the years of school attendance this growth leads, in many instances, to a myopic refraction. Indeed, as we pass from the lower to the higher classes in schools, we find myopia increasing steadily in frequency and in degree. The refraction remains stationary from the time of puberty, in healthy eyes. The increase of myopia so often noted from this time on until about the thirtieth year must be considered a morbid change.

35. Beyond the sixtieth year of age the refraction diminishes again, so that emmetropia turns into slight hypermetropia, on account of senile changes in the lens.

36. Accommodation.—According to the laws of refraction, the emmetropic eye can form sharp retinal images of those objects only which are situated at an infinite distance from the eye, or at least at a distance very large when compared with the dimensions of the refracting surfaces. Practically this amounts to any distance beyond five metres. But every-day experience teaches us that we can also see distinctly objects quite close to the eye; but we can never see equally distinctly, and at one and the same time, two objects, one far and the other near. On looking at a distant sign through a veil held in front of the eye, we can get alternately sharp images of the distant letters or of the threads of the adjacent veil, but we cannot see them both distinctly at one and the same time. This power of successive adjustment of the eye for distant and adjacent objects is termed the faculty of accommodation.

The exertion of the accommodation increases for the time being the refractive strength of the eye. It is evident that an eye accommodated for an object four inches distant must be equal in refractive strength to the emmetropic eye plus the strength of a convex lens of four inches focal length. For were the eye deprived of its power of accommodation it would be necessary to add to it the strength of this lens in order to get sharp retinal images of objects four inches off. The accommodative effort of an eye can therefore be represented by the strength of a convex lens of a focal length equal to the distance from the eye to the object accommodated for.

37. *Changes in the Eye during Accommodation.*—The optic changes upon which accommodation depends occur solely in the crystalline lens. Neither the corneal curvature nor the position of the retina is altered. Removal of the lens deprives the eye completely of its power of accommodation. Any eye, except one extremely myopic, becomes highly hypermetropic upon removal of the lens, requiring then a strong convex glass in order to see distinctly at a distance. On account of the impossibility to accommodate, the strength of this glass must be increased for near objects, and with a given glass accurate sight is possible only at one given distance. If the individual can read at different distances, it is done by ignoring the circles of diffusion, especially when they are small, on account of a narrow pupil. The most rigid test, whether in this or any other case an eye is adjusted for a certain distance, is known as Scheiner's experiment.

38. *Scheiner's Experiment.*—If some luminous point—for instance, a pin-hole in a screen in front of a light—be viewed through two pin-holes in another screen which are closer together than the diameter of the pupil, the only effect of the latter screen held close to the eye will be to diminish the number of rays, and thereby reduce the

brightness of the retinal image, if the latter be sharply defined on account of proper adjustment of the eye for the light. But if the eye is not adjusted for that distance, and circles of diffusion are formed on the retina, the screen with two perforators will cut off the rays forming the middle portion of the diffuse image, leaving instead two separate images of the luminous point, to which the eye is much more sensitive than to the circles of diffusion. Hence any want of adjustment causes the luminous point to appear double, as is evident from Fig. 47.

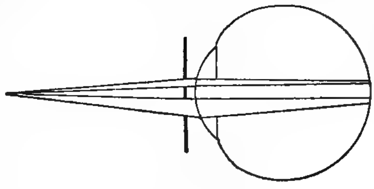

FIG. 47.

39. *Changes in the Shape of the Lens.*—During accommodation the lens becomes more convex, especially its anterior surface, which also moves forward on account of the thickening of the lens. If we place a light slightly to one side of an observed eye and watch the images reflected from the various surfaces, they will appear as seen in Fig. 48, *A*, while the observed eye looks at a distant object. When the eye observed is then adjusted for some near object, the images change, as seen in *B*, Fig. 48. The corneal image, *a*, remains the same in both cases. The reflection from the anterior surface of the lens, *b*, diminishes in size, indicating increased curvature of the surface, and moves laterally toward the corneal image, a motion referable to the advancement of the anterior surface of the lens. The small, sharply defined, and inverted image produced by the concave posterior surface of the lens shrinks likewise slightly in size, showing that the radius of curvature of that surface diminishes as well, though but little. No indication of any motion of the posterior surface can be observed. These changes in the curvature of the lens have been more accurately measured with the ophthalmometer, which shows that the radius of curvature can be reduced during a strong accommodative effort to about 6 mm. for the anterior surface, and about 5.5 mm. for the posterior surface of the lens, while the thickness of the lens may increase from 3.6 to 4 mm. Thereby the focal length of the lens in the diagrammatic eye would be reduced from 50.671 mm. during rest to 39 mm. during a strong accommodative effort. Calculating on this basis the refractive strength of the diagrammatic eye, we shall now find the principal posterior focus 1.644 mm. in front of the retina, while the retina itself is in the plane of focal reunion for rays coming from an object 146.6 mm. (not quite 6 inches) distant from the first principal point, which latter is 1.566 mm. behind the cornea in such an accommodated eye. Mathematical analysis thus confirms that the increased curvature and the advancement of the front surface of the lens suffice to account for the accommodative changes.

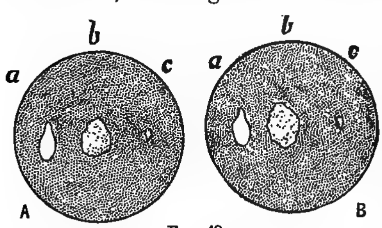

FIG. 48.

During accommodation the pupil diminishes in size. The utility of this contraction of the iris is evident on remembering that according to Section 4, the spherical aberration would increase with the divergence of the rays, and hence with the proximity of the object. On account of the advancement of the front surface of the lens the iris is also moved forward, which can be seen on looking in profile view at an eye during accommodation.

40. *Mechanism of Accommodation.*—The accommodative changes of the lens are brought about by the action of the ciliary muscle. The lens itself is not a muscular organ, it is devoid of contractility. It is, however, an elastic body kept stretched by its attachment to the annular ligament, as an elastic hoop would be flattened by the traction of two cords attached at two opposite points. Relieved of this traction the lens increases in convexity and becomes more nearly globular, so that the lens removed from the eye is more convex and thicker than while in place. During the accommodation effort the ciliary muscle contracts. Its meridional fibres pull the choroid forward. This has been shown by Hensen and Voelkers, by the movements of a needle put through the sclera and choroid on sending an electric current through the ciliary muscle in the eyes of animals and in a human eye just extirpated on account of disease. The circular, ring-shaped muscular fibres of the ciliary body on contracting cause the ciliary processes to project further toward the centre of the pupil, which movement of the processes is favored by the above-described traction on the choroid and consequent relaxation of its anterior insertion. In eyes in which a sufficiently extensive segment of the iris has been removed by the operation of iridectomy, and through the translucent intact iris of albinos this advancement of the ciliary processes toward the centre of the pupil has been directly observed. Since the ligament of the lens is attached to the ciliary processes the crowding of this ring-shaped structure into a narrower space necessarily relaxes the circular band stretched across the aperture within this ciliary ring. Thus the lens is permitted to retract by yielding to the tension of its own elastic substance; for the arrangement of the fibres of the lens-substance is such that they are relaxed by the approach of the lens toward the globular shape, while the flattening of the same by traction of its ligament puts them on the stretch. The changes in an eye during extreme accommodation are shown in Fig. 49, in which the upper half represents the front half of the eye at rest, and the lower half the contraction of the ciliary muscle and its effect upon the shape of the lens.

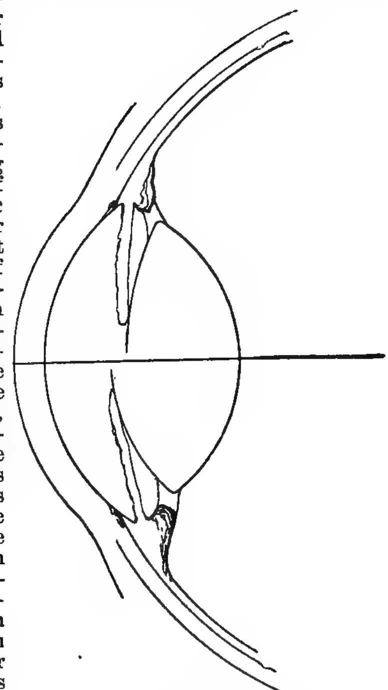

FIG. 49.

41. *Range of Accommodation.*—The most distant points of which the eye at rest can form a sharp image on its retina has been termed by Donders the *far-point* (punctum remotum = *R*) of the eye. In the emmetropic eye the far-point is—according to our definition of emmetropia—at an infinite distance. The myopic eye, however, cannot see distinctly beyond a certain short finite distance, depending on the degree of shortsightedness, while in hypermetropia the eye cannot bring into focal reunion on the retina any but convergent rays, and the far-point is therefore negative, that is to say, situated at some finite distance behind the eye. The fact that many hypermetropes can see distinctly at a distance with the unaided eye, is due to their using a part of their accommodation continuously in order to increase the actual refraction of the eye. The *near-point* (punctum proximum = *P*) on the other hand, is the nearest point of which the accommodated eye can get a well-defined image. The range of

accommodation is the total accommodative power which an individual eye possesses. We can represent it by the strength of the lens equivalent to the refractive difference between the eye at rest adjusted for the far-point and the eye accommodated for the near-point. Thus, an emmetropic eye, which can see distinctly an object as close as five inches, has a range of accommodation representable by a lens of five inches focal length or of the strength of about 8 D. For deprived of its accommodative power this eye would require such a lens to be held in front of it in order to get a sharp image of this near object on its retina. Practically, it will do to hold the lens very close to the cornea; for theoretical accuracy, however, the lens in question, of an infinite thinness, must be assumed situated in the first principal plane of the eye. The significance of the range of accommodation is made plainer by the use of Donders' formula,

$$\frac{1}{A} = \frac{1}{P} - \frac{1}{R},$$

in which we represent by A the range of accommodation, by P the near-point, and by R the far-point. This formula is applicable to ametropic eyes as well as to emmetropia, for anomalies of the refraction do not necessarily alter the range of accommodation. Thus a myope whose far-point is at twelve inches' distance, and who can accommodate for objects four inches from the eye has an accommodative range $= \frac{1}{4} - \frac{1}{12} = \frac{1}{6}$. Another instance will illustrate both the condition in hypermetropia and the use of the dioptric system. Suppose a certain hypermetropic eye, the axis of which is so short that it requires a correcting glass of 4 D in order to obtain sharp retinal images of distant objects. In this eye the far-point is negative, that is to say, it is situated twenty-five centimetres behind the anterior principal point. If this eye possesses an accommodative range equal to eight dioptrics, four of them are required to see distinctly at a distance and only 4 D are left, enabling the person to get distinct images of objects twenty-five centimetres distant by the extreme employment of his accommodation. Donders' formula reversed expresses this on using centimetres as follows:

$$\frac{1}{P} = \frac{1}{R} + \frac{1}{A},$$

which is in numerals

$$\frac{1}{P} = -\frac{1}{25} + \frac{1}{12\frac{1}{2}} = \frac{1}{25},$$

or employing dioptric notation, which is the reciprocal of the focal length,

$$P = -4\,D + 8D = 4\,D;$$

in other words, the distance of the near-point from the eye is equal to the focal length of a glass of 4 D strength = 25 centimetres.

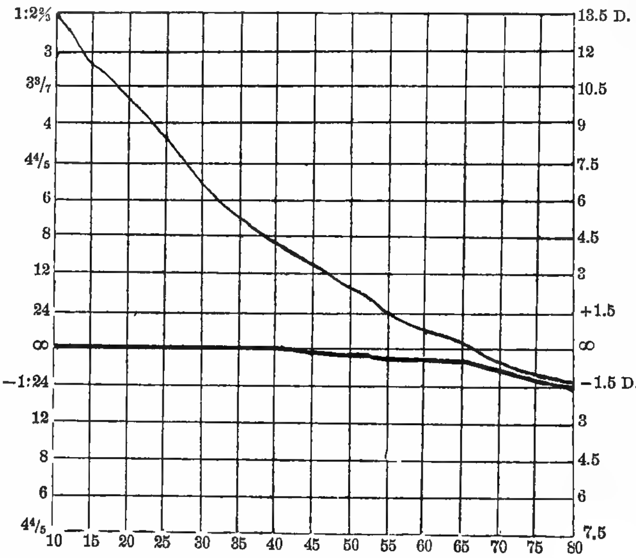

FIG. 50.

42. *Influence of Age on the Accommodation.*—From childhood on, the rigidity of the crystalline lens increases, and the extent of its elastic retraction diminishes. Hence the range of accommodation diminishes as the years advance, because the lens cannot retract as much in the later period of life as during youth, though the contracting ciliary muscle relaxes the annular ligament. The range of accommodation sinks thus from beyond ten dioptrics, during childhood, to zero toward the age of sixty years. Donders has constructed a diagram (Fig. 50), based on numerous observations, which illustrates this decline in a graphic manner. The heavy line represents the refraction of the eye at rest. As before stated, the emmetropic eye becomes slightly hypermetropic in advanced age, presumably from an actual flattening of the lens or a diminution of its refractive index. The range of accommodation extends from the heavier line of passive refraction to the thin line indicating the extreme active adjustment of the eye. The figures at the bottom give the age in years; those at the side the (active or passive) adjustment in French inches (or expressed in dioptrics on the right side). Occasionally deviations are found from this standard of decline. Thus, among others, the writer has seen a gentleman, seventy years of age, who could read the finest type up to eight inches' distance. He had a slight myopia and myopic astigmatism, less than 1 D, so that this accommodative range was still a trifle over 4 D, a very unusual amount for his age. Exceptions of the opposite kind, a falling short of the accommodative range normal to the age of the patient, are always due to disease of the eye or general impairment of the health.

43. *Innervation of the Accommodative Apparatus.*—The ciliary muscle derives its nerve supply from the third cranial nerve or motor oculi, which sends the motor root to the ciliary ganglion, whence issue the ciliary nerves which penetrate the sclera. It is a common clinical observation to find paralyses of other branches of this nerve accompanied by paralysis of the mechanism of accommodation. Experiments by Trautvetter[6] have shown that the fibres of accommodation run in the trunk of the motor oculi in pigeons, while in other animals the results were negative. In dogs, Hensen and Völkers have traced the fibres up to the floor of the third ventricle of the brain, as shown by the result on stimulating those parts.

Although the ciliary muscle consists of unstriated fibres in mammals, its movements are both as rapid and as much under the control of the will as those of any striated muscle. In birds, indeed, having evidently a very energetic accommodative mechanism, the ciliary muscle is striated. While the ciliary movements are voluntary in a certain sense, we are ordinarily not conscious of any accommodative effort. The movements of the ciliary muscle are guided by the retinal impressions which we get of the objects viewed, and may hence be classed among the complicated cerebral reflex movements. The accuracy of these movements is wonderful, inasmuch as the most rapid changes of adjustment of the eyes for different distances never give rise to any blurring of the images for which the eye accommodates. The regulating mechanism does not miscalculate the distance of the objects. The accommodating movements are always accompanied by an exactly corresponding convergence of the two eyes, so that in normal instances the object accommodated for is also the one toward which both eyes are directed, so as to place its image in the centre of the retina of each eye. The association of the movements of accommodation and convergence is so intimate that we cannot voluntarily perform either movement to any appreciable extent without the other. But by optic means,

which simulate the effect of one or the other movement, we can temporarily rupture the association. Thus, with a given degree of convergence for a certain fixed object, we can either force ourselves to a greater accommodative effort by looking through concave glasses, or relax the accommodation by means of convex spectacles. Similarly, we can vary the degree of convergence associated with a certain accommodative effort by placing prisms of variable strength and inclination in front of one or both eyes. The ability to separate these two movements ordinarily associated is increased by practice. It is evident that the correlation of the two movements, as well as the disturbance of this association by optic means, subserve the same purpose, viz., distinct vision without double images.

44. *Movements and Nerves of the Iris.*—On account of the association with the accommodation, the movements of the iris can be best discussed in this connection. The iris serves the purpose of an optic diaphragm, the aperture of which can vary in size according to necessity, the physiological limits being from two to six millimetres diameter. By reflex action the pupil contracts with increasing illumination, thereby diminishing both the fatiguing brightness of the retinal image and the width of any circles of diffusion due to optic imperfections. When the light is relatively feeble, a large pupil, on the other hand, permits a relatively greater brightness of the retinal images, while the enlarged circles of diffusion do not blur the sight so much, on account of their feebler intensity. The pupil contracts also with each accommodative effort, thereby diminishing the spherical aberration, which the proximity of the object and the increased convexity of the lens would produce. Independently of external light, the pupil is very narrow during sleep and during artificial narcosis. The mechanism of this latter contraction is not yet known. When the narcosis is interrupted by any sensory stimulation, or by asphyxia, the pupil indicates this change by dilatation.

The nerves of the iris are the ciliary nerves, coming from the ciliary ganglion, which, in man, has three roots —the short root from the motor oculi, the long root from the naso-ciliary branch of the fifth nerve, and the sympathetic fibres reaching the ganglion along with its arteries. The motor oculi controls the sphincter muscle of the iris. Its experimental irritation contracts the pupil; its section or accidental paralysis, allows it to remain dilated. The reflex pupillary contraction produced by light starts with the excitation of the optic nerve. When the optic nerves are rendered inactive by disease, the normal play of the pupils ceases, and they remain in a state of moderate dilatation. Excitation of one optic nerve, however, controls the pupils of both eyes, at least in those animals which, like man, have a visual field common to both eyes. Hence, in cases of unilateral blindness the two pupils are usually alike in size. The centre concerned in this reflex action is the anterior half of the tubercula quadrigemina (Budge). Various instances of disease of higher parts of the brain have been observed with integrity of these parts, and hence sensitiveness of the pupils to light, although conscious sight did not exist. According to Brown-Séquard the muscular tissue of the iris itself is somewhat sensitive to light, a tonic contraction being induced in it by strong light, even after extirpation of the eyeball.

The sympathetic nerve fibres control the dilator muscle of the iris. The existence of these radiating muscular fibres, which seemed pretty well established by the researches of Henle, Iwanoff, and Merkle, after much controversy with Gruenhagen, has lately been questioned again by Eversbusch (meeting of the Heidelberg Ophthalmological Society, September, 1884). He maintains that the radiating fibres in the posterior layer of the iris, which have been interpreted as smooth muscular fibres, are really nerve fibres, as shown by various staining methods. If these statements are corroborated, it will be impossible to account satisfactorily for the action of the sympathetic nerve on the iris. The view that these nerves change the size of the pupil, through their action upon the muscular walls of the blood-vessels of the iris, is not well supported by the facts.

Their course toward the eyeball is partly along the walls of the arteries, partly along anastomoses which join the fifth cranial nerve. Section or paralysis of the sympathetic nerve of the neck is followed by contraction of the pupil, while its irritation dilates that aperture. These fibres can be traced through the rami communicantes of the last two cervical and the first two dorsal nerves into the spinal cord (Budge and Waller). The reflex centre of these fibres is partly in the corresponding region of the spinal cord, and partly in the medulla oblongata. Reflex dilatation of the pupil through this nerve-channel can be readily induced by any sensory impression through most any sensory nerve, at least when the pupil is not contracted by strong light, especially during sleep and incomplete narcosis. The pupil, indeed, is very sensitive to irritations of sensory nerves. It is not known that this reflex dilatation is of any utility.

It has recently been asserted by Tuwim[7] that the superior cervical sympathetic ganglion maintains a slight tonus of the dilator nerves of the iris, independently of, and even after, its separation from the central nervous system. Although his experiments seem conclusive, the question should be further investigated, since this would be the first instance known of tonic activity of nerves maintained by a sympathetic ganglion.

The fifth cranial nerve is the sensory nerve of the iris, endowing it with very great sensibility. Irritation of this nerve contracts the pupil very energetically in some animals, for instance the rabbit. Section of the nerve has the same effect, temporarily, the fibres being evidently kept in a state of transitory irritation by the injury, as occurs as well in certain other nerves. This influence of the fifth nerve upon the pupil does not exist in carnivorous animals. The observations in disease of that nerve in man are too conflicting to be decisive. The study of eye diseases attended with irritation renders it very likely that in man the fifth nerve is the vaso-dilator nerve of the iris, and that its reflex excitation congests the iris and contracts the pupil mechanically by the engorgement of the vessels. This is also the most plausible explanation of the intense pupillary contraction obtained on puncturing the anterior chamber, which result does not occur on operating on the dead eye.

BIBLIOGRAPHY.—The optic properties of the eye were not understood until Kepler, in 1602, evolved the theory of optical instruments in general. The importance of the various parts of the eye in refraction was further elucidated by the Jesuit Scheiner in 1619. Minor additions were successively brought out by the labor of different authors, but it was only after Gauss had published his mathematical investigation of the cardinal points ("Dioptrische Untersuchungen," Göttingen, 1841) that the complete theory of the refraction in the eye could be deduced. This was done successfully by Listing, in the article "Dioptrik des Auges" in Wagner's "Handwörterbuch der Physiologie" (1853), who, by a critical selection of the older measurements of the refractive indices of the eye by Chossat and by Brewster, of the anatomical measurements of dimensions and curvature by Krause, Kohlrausch, and others, determined the position of the ocular cardinal points with considerable accuracy. The most marvellously accurate methods, however, for measurements of the living eye were first introduced by Helmholtz, who, in his "Handbuch der physiologischen Optik" (1867), has produced a masterly treatise of rare originality, which every student of the subject must consult in the original. Since the publication of his large work, the first part of which on refraction appeared in 1856, Helmholtz has pursued these studies with the aid of numerous students, most of whose articles have appeared in the running numbers of the *Archiv für Ophthalmologie.* In an article by Reich (*Arch. f. Ophth.*, 1874, vol. xx., 1), Helmholtz corrects some of his former measurements and figures, and accepts as more nearly representing the values of the cardinal points in the average eye the figures which we have reproduced in the text of this article. Extensive measurements, especially of the curvature of the cornea, have also been made by Donders ("Anomalies of Accommodation and Refraction," 1864) and by Mauthner ("Vorlesungen

über d. optischen Fehler des Auges," 1872), and more recently by Reuss (*Arch. f. Ophthalmologie*, xvii., 1, p. 27). The entire theory of the formation of images in the eye, including physiological optics in general, is most exhaustively treated in Aubert's "Grundzüge der phys. Optik," in vol. ii. of Graefe and Saemisch's "Handbuch der gesammten Augenheilkunde" (1876), while important recent additions are to be found in Nagel's "Anomalien der Refraction," in vol. vi. of the same work. Very complete is also the treatise of Fick in vol. iii. of Hermann's "Handbuch der Physiologie." All of these works must be consulted for the complete literature of the subject. In the English language the most extensive but older treatise is the work by Donders on "Anomalies of Accommodation and Refraction" (1864), which book marked quite an era in our knowledge of the physics of the different refractive conditions of the eye. In connection with this latter subject the work of Jaeger ("Einstellungen d. dioptrischen Apparats," 1861) must also be mentioned.

The mechanism of accommodation has been extensively discussed by former authors, by whom, however, no facts were brought forth beyond those taught by every-day observation. By some the accommodative changes were referred to the variations in the size of the pupil, while others even denied the existence of any accommodation. The most complete mathematical discussion was furnished by Th. Young in the "Philosophical Transactions" of 1801, in which it was shown by experiments and by deductions that the accommodation cannot depend on any changes except those in the form of the lens. The experimental proof that such changes do occur was furnished simultaneously and independently of each other by Cramer (in various publications in the Dutch language, between 1851 and 1855) and by Helmholtz (*Monatsberichte d. Berliner Academie*, February, 1853). The mode of action of the ciliary muscle was first explained by Helmholtz theoretically, and has since been confirmed experimentally by Hensen and Völkers, who have likewise studied the innervation of the accommodative apparatus ("Experimentaluntersuchung über den Mechanismus der Accommodation," 1868, and *Archiv f. Ophthalmologie*, 1873, vol. xix.). Important measurements of the changes in the curvature of the lens during accommodation, and a mathematical inquiry into their efficiency were published by Knapp (*Archiv f. Ophth.*, 1860, vols. vi. and vii.). Our knowledge of the range of accommodation in health and disease is due mainly to the researches of Donders ("Anomalies of Accommodation and Refraction").

On the innervation of the iris there exists an extensive literature, scattered throughout numerous physiological and ophthalmic serials. The older literature is exhaustively compiled in Budge's "Bewegungen der Iris," 1855. The present writer presented likewise a full review of the physiology of the iris in the *Chicago Journal of Nervous and Mental Diseases* (April and July, 1874), in which the complete literature up to that date can be found. Whatever has been done since 1874 is explicitly referred to in the text.

H. Gradle.

[1] Nagel: Anomal. d. Refraction, in Graefe and Saemisch's Handb. d. ges. Augenheilkunde, p. 461.
[2] Ueber schiefen Durchgang von Strahlenbündeln durch Linsen, Gratulationschrift an C. Ludwig. 1874.
[3] Archives of Ophthalmology, vol. ix, p. 29.
[4] Proceedings of the International Congress at Copenhagen, 1884, Ophthalmic Section.
[5] Report of the Heidelberg Ophth. Society in Deutsche med. Wochenschrift, October 9, 1884.
[6] Archiv f. Ophthalmologie, 1866, xii., p. 95.
[7] Archiv f. d. gesammte Physiologie, Bd. xxiv., p. 115.

ACCOMMODATION AND REFRACTION. PATHOLOGY.—The normal refractive condition of the eye (*emmetropia*, E) is best described as a correct relation between the curvatures of the refractive surfaces and the length of the antero-posterior diameter (axis) of the eyeball. In emmetropia, parallel rays, such as are received from any distant object, are accurately focussed upon the retina by virtue of the refractive power of the eye, without aid from the accommodation. If this normal relation is disturbed, whether through abnormal curvature of the cornea or the anterior or posterior surface of the crystalline lens, or through a variation from the normal length of the axis of the eyeball, a refractive anomaly (*ametropia*) is the result.

In the two principal types of ametropia the axis of the eyeball is actually, in most cases, either too short or too long. In the former case the refractive power of the eye is insufficient to focus parallel rays accurately upon the retina, and some exercise of the accommodation is necessary for distinct vision at a distance. For the focussing of divergent rays, such as are received from any near object, the accommodative adjustment is necessarily in excess of that which the emmetropic eye employs for distinct vision at the same distance, and this excess is always equal to the degree of accommodation required for vision at a distance. From the fact that the focus for parallel rays is behind or beyond the retina, this refractive anomaly has received the name *hypermetropia*, H (from ὑπέρμετρος, overmeasure, and ὤψ, eye). The hypermetrope, if his accommodation is sufficient to overcome the refractive deficiency, may see distinctly at all distances, but only through active accommodative effort, and generally with more or less sense of fatigue, when the eyes are used continuously. Moreover, as the range of the accommodation has always a nearly definite limit, which is closely related to the age of the subject, the nearest point of distinct vision (near-point, *p*) is always somewhat further from the eye than in emmetropia. Hypermetropia is ordinarily an inherited condition, and may be properly considered as a form of incomplete development of the eyeball. (See Hypermetropia.)

In the case of an abnormally long axis of the eyeball, parallel rays are focussed in front of the retina, and only divergent rays are focussed accurately upon it. Such an eye is, therefore, fitted only for near vision, and for this reason is called near-sighted or short-sighted. Shortsightedness was known to the classical writers, who mention it under the fanciful name *myopia*, thus precluding the adoption of the really descriptive name *brachymetropia* (from βραχύ, short, μέτρον, measure, and ὤψ, eye), as suggested by Donders to express the opposite condition to hypermetropia. The myope sees all distant objects indistinctly, and he sees objects at some definite shorter distance (far-point, *r*) clearly, without exercise of the accommodation. For objects which lie nearer to the eye than its far-point, the myope accommodates, but always less than does the emmetrope for the same distance. When the myope makes use of his entire accommodation he is able to see clearly at a somewhat shorter distance (near-point, *p*) than can the emmetrope under the same condition of full accommodation. Myopia is generally an acquired condition, and is then the result of pathological distention of the eyeball. (See Myopia.)

The emmetropic eye has its far-point at an infinite distance, and its near-point at some short distance, which is determined by its range of accommodation. At the age of twenty years this is equal to about ten metric units (*dioptrics*[1]), and the near-point is about one-tenth of a metre (10 ctm. = 4 in.) from the eye. In myopia the grade of the refractive anomaly, expressed in dioptrics, determines the position of the far-point, and from this the near-point may be found by adding the number of dioptrics which expresses the range of the accommodation. With a myopia of five dioptrics (5 D), and a range of accommodation of ten dioptrics (10 D), the far-point is one-fifth of a metre (20 ctm. = 8 in.) from the eye, and the near-point is about one-fifteenth ($\frac{1}{5+10} = \frac{1}{15}$) of a metre (6.6 ctm. = 2.6 in.) from the eye. In hypermetropia the grade of the refractive anomaly is similarly expressed in dioptrics, but with the minus (—) sign, and the place of the near-point is determined by the algebraic sum of this minus quantity and the plus (+) quantity which represents the range of the accommodation. With a hypermetropia of five dioptrics (— 5 D), and a range of accommodation equal to ten dioptrics (10 D), the place of the near-point is determined by the algebraic addition of those two quantities (10 D — 5 D = 5 D), and is one-fifth of a metre (20 ctm. = 8 in.) from the eye. In a higher grade of hypermetropia, say of ten dioptrics (10 D), with a range of accommodation equal to ten diop-

trics (10 D), this addition (10 D − 10 D = 0 = $\frac{1}{\infty}$) places the near-point at an infinite distance, which means that the full exercise of the accommodation is only sufficient for distinct vision at a distance, and that the eye has no accommodation to spare for vision at shorter distances. In a still higher grade of hypermetropia, say of fifteen dioptrics (− 15 D), with the same value of ten dioptrics (10 D) for the range of accommodation, we find 10 D − 15 D = − 5 D, or, in other words, a virtual hypermetropia of five dioptrics (− 5 D), notwithstanding the full exercise of the accommodation. In the highest grades of hypermetropia there is no distinct vision at any distance.

It is only in emmetropia that the entire range of the accommodation is available for distinct vision at all distances from infinity to the normal near-point. In ametropia the range of accommodation remains unchanged, but the limits within which it acts are displaced, so that it is rendered less effective in adjusting the eye for distinct vision at different distances. This *region of accommodation* may vary greatly in extent according to the kind and degree of the ametropia. In myopia it is limited for distance by the far-point (r) and for the near by the near-point (p), and the higher the grade of the myopia the nearer are these two points to each other. In hypermetropia a part of the accommodation is expended in the adjustment of the eye for vision at a distance, and the region of accommodation is correspondingly curtailed through the recession of the near-point from the eye. Moreover, in hypermetropia the accommodation is overtaxed, and, even within its actual limits, its exercise is attended with some degree of strain and consequent fatigue. Lastly, as the range of accommodation diminishes with increasing age, the near-point recedes more rapidly than in emmetropia, until it passes the limit of distance at which reading is possible, and premature old sight (*presbyopia*) is developed.

The positions of the far-point (r) and of the near-point (p), respectively, are measured, in metres and centimetres, from the anterior nodal point of the eye, which is situated in the crystalline lens near its posterior surface. Representing these distances by R and P, respectively, the range of accommodation, expressed in dioptrics, by A, and the degree of myopia or of hypermetropia, expressed also in dioptrics, by M or H, respectively, we have:

In *emmetropia*, $$R = \frac{1}{0} = \infty, \quad P = \frac{1}{A};$$

in *myopia*, $$R = \frac{1}{M}, \quad P = \frac{1}{M + A};$$

in *hypermetropia*, $$R = -\frac{1}{H}, \quad P = \frac{1}{A - H}.$$

As, however, the actual limit of vision for distance is infinity, this must represent the position of the far-point (r) in hypermetropia, and the expression of the real condition becomes:

In *hypermetropia*, $$R = \infty, \quad P = \frac{1}{A - H}.$$

From a comparison of these formulæ it will be seen that, with the same range of accommodation, the region of accommodation is most extensive in emmetropia. In myopia this region is greatly contracted through the approach of the far-point (r), with but slight and generally unimportant compensation in the approach of the near-point (p) to the eye. In hypermetropia the region of accommodation is seriously curtailed through the recession of the near-point (p) from the eye, while the far-point (r) remains, as in emmetropia, at infinity.

By the correction of the ametropia, by means of the proper concave or convex glass, the far-point (r) is adjusted to infinity, and the near-point (p) is then determined solely by the range of accommodation (A). The formula then becomes indentical with that of emmetropia:

In *myopia* $$R = \frac{1}{M - M} = \frac{1}{0} = \infty, \quad P = \frac{1}{M - M + A} = \frac{1}{A};$$

in *hypermetropia*, $$R = \frac{1}{H - H} = \frac{1}{0} = \infty, \quad P = \frac{1}{H - H + A} = \frac{1}{A}.$$

We have thus far considered only the case of ametropia as if in a single eye, and have ignored all complications growing out of the fact that vision is actually the result of the concurrent action of the two eyes. In brief, it may be stated that we see with each eye the object or part of the object to which the eye is directed, and that in order to see the same object with the two eyes, the two eyes must be accurately directed each to the same point, and this point must be a point for whose distance each eye is accommodated. There is, in fact, a very intimate connection between the two adjustments of accommodation and *convergence*, which may lead to important complications both in myopia and in hypermetropia. In myopia, we have seen that there is comparatively little occasion for the exercise of the accommodation, but the need for convergence remains unchanged, or may even be somewhat increased by reason of the shorter distance at which the strongly myopic eye sees small objects. This normal, or excessive, convergence may in turn evoke excessive accommodation, and so necessitate the holding of the book still nearer to the eyes, thus again necessitating still stronger convergence. The needless accommodation which is thus excited may cause the myopic eye to appear more strongly myopic than it really is, and may lead to injurious *tension of accommodation*, and through this to a progressive increase in the grade of the myopia. On the other hand, the eyes may fall into the habit of relaxing the accommodation to the degree requisite for distinct vision at or near the far-point, and this relaxation of the accommodation may be attended by a corresponding relaxation of the convergence, which may lead to weakness or insufficiency of the recti interni muscles (*muscular asthenopia*), and ultimately to divergent strabismus. In hypermetropia, as we have seen, the eyes accommodate even in distant vision, and must accommodate more strongly than in emmetropia in order to see near objects distinctly. Accordingly in hypermetropia one of two complications may arise; either the convergence may be habitually adjusted to the distance of the object, in which case the correlated degree of accommodation may be insufficient for distinct vision or for continuous work, and so the eyes may suffer from accommodative insufficiency or fatigue (*accommodative asthenopia*); or, on the other hand, the accommodation may be maintained to the degree requisite for distinct vision, and this excessive accommodative effort may evoke a tendency to excessive convergence, which may ultimately develop into convergent strabismus. (See Strabismus.)

The effect of the disturbed correlation between the accommodation and the convergence in ametropia may be concisely formulated, as follows:

In myopia there is a tendency to abnormal tension of the accommodation, and through this to a progressive increase in the grade of the myopia, or else to muscular asthenopia and insufficiency of the recti interni muscles, and ultimately to divergent strabismus.

In hypermetropia the tendency is to fatigue or insufficiency of the accommodation (accommodative asthenopia), or else to abnormal tension of the recti interni muscles, and ultimately to convergent strabismus.

Astigmatism is a refractive anomaly in which the refractive power of the eye is unequal in different meridians (see Astigmatism). This inequality is greatest in two meridians which lie at right angles to each other, and

which are called the principal meridians. The astigmatic eye may be emmetropic in one of its principal meridians, in which case it is either myopic or hypermetropic in the other; or it may be either myopic or hypermetropic in both meridians; or, lastly, it may be myopic in one of its principal meridians and hypermetropic in the other. If the astigmatic eye is hypermetropic in its horizontal meridian, the accommodative disturbances are generally those which belong to hypermetropia, namely, accommodative asthenopia, or a tendency to convergent strabismus; if, on the other hand, the eye is myopic in its horizontal meridian, the complications are ordinarily those which belong to myopia, namely, accommodative tension, or muscular asthenopia, or insufficiency. Moreover, as in astigmatism the acuteness of vision is more or less impaired, the inclination is always to hold the book quite near to the eyes, and thus the tendency to accommodative tension or to muscular insufficiency, on the one hand, or to muscular tension, or to accommodative insufficiency, on the other hand, is materially aggravated.

Irregular astigmatism (see Astigmatism) necessarily impairs the acuteness of vision at all distances, and may prove a source of disability or of danger through the forcing of the accommodation and convergence in the effort to read continuously at a very short distance.

The correction of astigmatism, together with any accompanying ametropia, by means of appropriate cylindrical or spherico-cylindrical glasses, both improves the acuteness of vision and removes the disabilities incident to the displacement of the region of accommodation. Even in irregular astigmatism a part of the refractive defect may often be corrected by means of cylindrical glasses, with corresponding improvement in the acuteness of vision.

Unequal refraction in the two eyes—*anisometropia* (from α privative, ἴσος, equal, μέτρον, measure, and ὤψ, eye)—may give rise to certain complications growing out of the close connection between accommodation and convergence. Moreover, as the accommodation is always equal in the two eyes, the same degree of inequality must exist in accommodation as in a state of rest, so that the two eyes are never accurately accommodated for the same distance at the same time. In order to see any object clearly, one of the eyes must accommodate accurately for its distance, while the other eye is necessarily accommodated for some other distance. Hence, one of the retinal images is distinct, while the other is imperfectly defined. This difference in definition is, however, not of much importance, for, practically, the attention is attracted to the clearer image, and the confused details of the other image are disregarded. Both images are, however, utilized in binocular vision, as is shown by the persistence of the faculty of estimating differences of distance and of appreciating the form of solid objects (stereoscopic vision). On theoretical grounds a certain improvement in the acuteness of vision might be expected from the accurate correction of both eyes by means of glasses of different foci, and this is undoubtedly true in the case of lesser differences in refraction, but in cases of greater difference, equalizing glasses may not be readily accepted. A person with one emmetropic eye of normal acuteness will not ordinarily accept glasses for the sole purpose of remedying a visual defect of which he is perhaps unconscious and which causes him no inconvenience, and, similarly, most persons with ametropia of a different grade in the two eyes will rest satisfied with glasses of equal foci, which leave the existing refractive difference unchanged. Hence the general rule not to give glasses for an uncomplicated refractive error of one eye, and, except in the case of a trifling difference (one dioptric or less), to give glasses of equal foci, selected with reference to the eye which is habitually in use, in cases of uncomplicated refractive error of a different grade in the two eyes.

The complications which may make it necessary to prescribe glasses of different foci in anisometropia occur chiefly in cases of myopia of one eye, or of myopia of a different grade in the two eyes. In myopia of one eye, with emmetropia or moderate hypermetropia of the other, the myopic eye is ordinarily used in reading and the emmetropic or hypermetropic eye in distant vision. Such a person may suffer from muscular asthenopia or insufficiency of the recti interni, as a consequence of the habitual relaxation of the accommodation in reading, or from injurious tension of the accommodation, with a tendency to progressive increase of the grade of myopia, incident to the habit of converging accurately for the reading distance. In such cases it is generally best to correct the myopic eye by means of a suitable concave glass, and to prescribe for the other eye either a plane glass or a convex glass suited to the grade of its hypermetropia. In myopia of a different grade in the two eyes it is the rule to correct the less myopic eye for distance, and to give the same glass, or one of shorter focus, to the more myopic eye, as may be found most satisfactory upon trial. If the difference in the refraction of the two eyes is large (two dioptrics or more), a partial correction of the more myopic eye may be preferred in the beginning, and the full correction may be demanded after the lapse of a few weeks or months.[2]

Aphakia (from α, privative, and φακός = *lens*, a lentil) is the condition in which the crystalline lens is either wholly wanting or is so displaced that it no longer lies in the axis of the eyeball. Of the total refraction of the eye (about 50 dioptrics) about five-eighths (31.5 dioptrics) is due to the cornea, and about three-eighths (18.5 dioptrics) is due to the crystalline lens. The aphakial eye has therefore sustained a loss of refractive power equal to 18.5 dioptrics, besides the loss of its entire accommodation, which in youth amounts to about ten dioptrics more. In correcting aphakia by means of a convex glass, the position of the glass (about half an inch in front of the cornea) is considerably more advantageous than that of the crystalline lens which it replaces, and consequently a glass of about eleven dioptrics is sufficient, in most cases, to make good the refractive deficiency. The retinal image is also enlarged by about one-third, in consequence of the change in the position of the nodal point. A certain degree of accommodation, with additional enlargement of the retinal image, may be obtained by holding the glass farther from the eye, but the distance at which the glass can be easily held is limited to the length of the nose, and is too small to admit of the necessary adjustment for reading. Hence two glasses are generally required, a weaker glass, of ten or eleven dioptrics, for distant vision, and a stronger glass, of fourteen or fifteen dioptrics, for reading. If the aphakial eye is of hypermetropic construction, proportionally stronger glasses, and if of myopic construction, proportionally weaker glasses, are required. In the case of aphakia of one eye, with normal visual acuteness of the other eye, it is hardly practicable to equalize the refraction, even for distance, by means of glasses of different foci; but the aphakial eye, though uncorrected, takes some part in binocular vision, and is of use not only by enlarging the general field of vision, but also by assisting in the estimation of distances. A considerable grade of astigmatism is frequently present in aphakia, which may be due either to original asymmetry of the cornea or to an acquired distortion of the cornea incident to the healing of the incision in the operation for the extraction of cataract. Low grades of astigmatism are often overcome by looking obliquely through the strong convex glasses worn to correct the aphakial condition; higher grades may require correction by a spherico-cylindrical lens. (See Astigmatism.)

Disorders of accommodation may occur as a result either of an abnormal condition of the special organ of accommodation, the crystalline lens, or of disordered innervation.

The absence of the crystalline lens involves not only a notable reduction in the refractive power of the eye, but also the total loss of accommodation.

Cases of *ectopia lentis* (from ἔκτοπος, out of place), and of incomplete luxation of the crystalline lens from injury to the eye have been observed, in which the lens has remained nearly, or quite, transparent. In such cases the refractive power of the eye is generally considerably increased, owing probably to an increase in the convexity of

the lens, but the faculty of voluntary accommodation is wholly wanting.

The progressive hardening of the crystalline lens, which has already begun in youth, and which goes on, probably, throughout the entire duration of life, becomes, after middle life, an insurmountable obstacle to such changes in the form of the lens as are essential to perfect accommodation for the usual reading distance (see Presbyopia). Only in myopia is there an apparent exception to this statement, owing to the fact that the far-point (r) often lies so near to the eye as to bring it within the ordinary reading distance of thirty centimetres (twelve inches). In such cases the myope never becomes presbyopic in the sense of being unable to read without the aid of convex glasses; but whereas in youth he reads easily with the concave glasses which perfectly correct his myopia, he is compelled, with advancing age, either to lay aside his glasses in reading, or to exchange them for weaker concave glasses than those through which he sees well at a distance. In hypermetropia, on the other hand, the loss of accommodation shows itself by an early recession of the near-point (p), so that help is sought from convex glasses, perhaps long before the usual age of from forty to forty-five years. Still the hypermetrope, wearing convex glasses which correct his hypermetropia, is able both to see at a distance and to read, and it is only at the age of about forty-five years that he finds himself compelled to exchange these glasses for stronger reading glasses. Under no circumstances can a presbyope see clearly at a distance and read easily with the same glasses. Either he is an emmetrope, in which case he requires convex glasses for reading, but none for distant vision; or he is a myope, and so requires concave glasses for the distance, and weaker concave glasses, or no glasses at all, for reading; or he is a hypermetrope, and so sees distinctly at a distance with convex glasses, but requires stronger convex glasses for reading.

Paralysis or paresis of accommodation from defective innervation may be the result of an affection implicating the terminal branches of the ciliary nerves, or any part of the nervous tract between these and the central origin of the motor-oculi nerve in the ganglia and cortex of the brain. With rare exceptions it is accompanied by dilatation and loss of mobility of the pupil (*mydriasis*), and in many cases also by paralysis or paresis of one or more of the ocular muscles supplied by the motor-oculi nerve, namely, the levator palpebræ superioris, the rectus superior, the rectus inferior, the rectus internus, and the obliquus inferior.

A typical example of paralysis of accommodation dependent on impairment of the function of the terminal branches of the ciliary nerves, is that which follows the instillation of a mydriatic solution into the conjunctival sack. Within fifteen minutes after the instillation of a drop of a solution of atropia sulphate of a strength of one per cent. (1 : 100), the pupil begins to dilate, and within half an hour the dilatation reaches its maximum, and the pupil no longer contracts under the stimulus of strong light. Shortly after the establishment of full mydriasis, or about half an hour after the instillation, the near-point (p) begins to recede rapidly from the eye, and the paralysis of accommodation is complete at the end of an hour and a half. The dilatation of the pupil and the paralysis of accommodation continue without sensible change for about two days, after which both begin to pass away, the former very gradually, the latter more rapidly for two or three days and afterward more slowly, until at the end of ten or twelve days the effect of the drug disappears altogether. The effect of very weak solutions of atropia, say of a strength of one-hundredth of one per cent. (1 : 10,000) is to dilate the pupil in the course of an hour and a half or two hours, but without rendering it immovable under the influence of bright light, and without greatly affecting the accommodation. Under the action of atropia the near-point (p) recedes from the eye until it comes to coincide with the far-point (r). Hence the visual disturbance varies very conspicuously according to the refractive condition of the eye. In emmetropia distant vision remains clear, but accommodation for the near is rendered impossible; in hypermetropia vision becomes indistinct for the distance, and still more so for the near; while in myopia of a rather high grade there may be no trouble in reading, and the loss of accommodation, within the narrow limit of distance between the far-point and the near-point, may give rise to little inconvenience or may even pass unnoticed. To the hypermetrope or myope wearing glasses which correct his refractive defect the visual disturbance is the same as in emmetropia. Several other plants, belonging mostly to the natural family *solanaceæ*, or to a closely allied order, yield alkaloids whose action is nearly identical with that of atropia, and quite recently a valuable mydriatic property has been discovered in cocaine, the active principle of *erythroxylon coca.*

Concussion of the eyeball is sometimes followed by weakening or loss of the accommodation, conjoined with dilatation of the pupil. This condition may soon pass away, or it may be permanent. It is evidently the result of injury to the ciliary nerves, in the ciliary region of the eye.

Diphtheria is often followed by paresis of accommodation, with some enlargement of the pupils. It occurs, as a rule, after recovery from the throat affection, and has ordinarily a duration of several weeks, or perhaps of two or three months. It is frequently associated with paresis of the palatine muscles, giving rise to characteristic alteration of the speech. The external muscles of the eye are seldom affected, but cases of true convergent strabismus have been observed as a result of excessive efforts to accommodate in the weakened condition of the accommodative apparatus. The symptoms of paresis of accommodation following diphtheria are essentially the same as in asthenopia resulting from the overloading of the accommodation in hypermetropia, and the use of convex glasses is often indicated as an aid in reading during the continuance of the disability; the instillation of a drop of a weak solution of pilocarpine, two or three times a day, is also of positive utility in many cases.

Syphilis is recognized as an occasional cause of paralysis of accommodation with mydriasis. It occurs ordinarily as one of the later manifestations of the disease, and is not generally amenable to treatment.

Pressure upon the ciliary nerves, from intraorbital hæmorrhage, inflammatory exudation, tumor, etc., may give rise to loss of accommodation and dilatation of the pupil, without affecting the function of any of the external muscles of the eyeball.

In lesions affecting the conductivity of the motor-oculi nerve, the accommodative disturbance and dilatation of the pupil are accompanied by paralysis of the levator muscle of the upper lid, of the recti muscles (excepting the abducens), and of the inferior oblique muscle.

Mydriasis, with loss of accommodation, may occur as a symptom of intracranial disturbance, affecting the central origins of the motor-oculi nerve. Such disturbance may be the result of a pathological process (syphilis, embolism, etc.), in which case it is apt to be associated with paralysis of one or more of the external muscles of the eyeball.

Exposure to sudden changes of temperature, sitting in a cold draught, etc., are sometimes followed by paralysis of one or more of the motor nerves of the eye or of the eyelid. These cases, which, in the absence of positive knowledge, are generally designated as rheumatic, end frequently in perfect recovery after a few days or weeks; in other instances they prove rebellious to all treatment.

The constitutional effect of an overdose of any one of the common mydriatic drugs (belladonna, datura, hyoscyamus, duboisia), administered by the stomach or hypodermically, is marked by conspicuous dilatation of the pupils, with loss of accommodation. If the patient survives the toxic influence, these symptoms disappear after a short time.

True spasm of accommodation, as distinguished from the condition of accommodative tension already noticed in connection with ametropia, is of quite rare occurrence, and is a result of irritation of the ciliary nerves or the oculo-motor nerve-centres,[3] or of a paralytic affection of the cervical sympathetic. It is associated with contraction of the pupil (*myosis*), and is the exact opposite of accom-

modative paralysis with mydriasis. Certain drugs (*myotics*), instilled into the conjunctival sack, have the property of evoking accommodative spasm with myosis, which may be studied by observing the action of a single drop of a solution of eserine sulphate (the active alkaloid of Calabar bean) of the strength of one-half of one per cent. (1 : 200). Contraction of the pupil and spasm of accommodation begin nearly simultaneously within about ten minutes, and both reach a maximum in from thirty to forty minutes. After about two hours, the far-point (r), which at the height of the action of the drug is not over twenty centimetres (eight inches) from the eye, is found to have receded to its normal position (∞ in the emmetropic eye), but the near-point, in voluntary accommodation, is considerably nearer to the eye than normal after the lapse of six hours, thus showing a positive increase in the range of accommodation. The contraction of the pupil begins to diminish after about two hours, at first slowly, then more rapidly for about four hours more, and afterward slowly until, at the end of two days, the pupil has nearly or quite regained its normal diameter. With a weaker solution of eserine the spasm of accommodation is much less than with the half per cent. solution, and is painless; with the stronger solution the action is accompanied by a sensation of spasmodic twitching, and with some pain. Pilocarpine, the active alkaloid of jaborandi, is much milder in its action than eserine, but is nevertheless an efficient myotic, and exerts also a very positive effect in stimulating the accommodation.

Contraction of the pupil is frequently observed in central nervous affections, and notably in tabes dorsalis. Myosis, with spasm of the accommodation, follows also the administration of large doses of eserine, opium, and, probably, some other drugs, internally. The internal or hypodermic use of pilocarpine does not produce contraction of the pupil or spasm of accommodation.

John Green.

[1] Dioptric (or dioptry), a word proposed by Monoyer to designate the unit of the metric system; it is the generally received expression for a lens of one metre focal length, which is almost exactly equivalent to the glass numbered 40 ($^1/_{40}$) in the old French system.

[2] In a case of myopia of 4.5 dioptrics in the right eye, with hypermetropia of 5.5 dioptrics in the left eye, which came under the care of the writer about ten years ago, the right eye was first corrected by a concave glass of 4.5 dioptrics, and a plane glass was given for the left eye. The patient, a young man of eighteen years, was well satisfied with those glasses for a few weeks, and then demanded a correction for the left eye. At the end of ten weeks he was wearing correcting glasses for both eyes with comfort, and still wears the same glasses with entire satisfaction.

[3] Irritation of the fifth cranial nerve (ophthalmic division) is followed by contraction of the pupil, and the same phenomenon may attend irritation of the terminal branches of this nerve in the cornea. Myosis from this cause may also be attended with spasm of accommodation.

ACETABULUM, Fractures of, may be divided into compound and subcutaneous, or, as regards their causation, into direct and indirect. The hip-joint is so deeply situated and so efficiently protected by the surrounding bony projections and soft tissues against direct violence that fractures produced in this manner almost invariably belong to the compound variety, and, in the great majority of cases, they are the result of gunshot injuries. Gunshot wounds of the hip-joint, with or without fracture of the acetabulum, have always been considered by surgeons as formidable and dangerous lesions. Pirogoff made the statement that during the Crimean War all injuries of this kind proved fatal. During the war of the Rebellion nearly all cases of gunshot injuries of the hip-joint treated on the conservative plan resulted in death. Of 63 cases of similar injury where resection was performed, only 5 recovered. In his classical treatise on this subject, B. von Langenbeck collected 119 cases which occurred during the Franco-Prussian war, with 29 recoveries; 88 were treated on the expectant plan, with 25 recoveries; 31 were submitted to excision, with 4 recoveries.

The acetabulum may be fractured without injury of the head or neck of the femur, as the bullet may impinge upon the floor of the acetabulum, from within the pelvis, with sufficient force to break the bone, producing a fissure or stellate fracture of its base, or it may, in its course, carry away the rim of the cotyloid cavity. An exceedingly interesting case, illustrating the latter assertion, is reported by Dr. J. F. Miner, of Buffalo (*Buffalo Med. and Surg. Journal*, vol. v., p. 383). Lieutenant-Colonel James Strong, of the Thirty-eighth New York Volunteers, was wounded, May 5, 1862, at the battle of Williamsburg, Va. The ball entered a little below the anterior superior spinous process of the ilium, and made its exit near the outer margin of the sacrum. The ball passed deeply, and fractured, in its course, the rim of the acetabulum, which was removed, an inch and a half in length, and of a diameter sufficient to show that the whole upper rim had been carried away. This fragment of bone was removed from the wound at the dressing made in the hospital to which he was carried, after having lain on the field for some hours. The wound was very large, and a thorough examination could be made by the easy passage of the finger. The patient passed through a serious and prolonged illness from the suppuration and hectic fever which followed, but finally recovered, with five inches shortening of the limb, inward rotation of the foot, and bony anchylosis between the dislocated thigh-bone and the ilium. The points of entrance and exit of the projectile furnish valuable information in regard to the probable injury of the acetabulum in gunshot fractures of the hip-joint. In the case just reported, the ball entered just below the anterior superior spinous process of the ilium, and passed out near the margin of the sacrum, leaving intact the head of the femur, but opening the hip-joint by carrying away the superior and posterior margin of the rim, thus permitting the subsequent dorsal dislocation of the head of the femur by muscular force. B. von Langenbeck states that, in case the ball enters directly below and toward the outer side of the spine of the pubes, and takes its exit in the region behind the greater trochanter of the same side, as a rule it penetrates the hip-joint; and, at the same time, it fractures in its course the upper rim of the acetabulum. Escape of synovial fluid, swelling in the region of the hip-joint from extravasation of blood or the products of inflammation, preternatural motion in the joint, crepitation, and dislocation of the head of the femur spontaneously, or on manipulation, are other important diagnostic symptoms. The most important information regarding the exact nature of the injury is, however, obtained by enlarging the track of the bullet and rendering the hip-joint accessible to touch and sight. This procedure, done under antiseptic precautions, affords not only an opportunity to ascertain the true nature and gravity of the injury, but it is imperatively called for as the first and most important step in the treatment. All foreign bodies and detached pieces of bone should be removed, all hæmorrhage carefully arrested, and the whole injured surface and surrounding parts thoroughly disinfected; effective drainage should be established, and every possible source of infection guarded against by dressing the wound antiseptically. All these measures are essential, as the success of the operation and the life of the patient depend on procuring and maintaining an aseptic condition of the wound. The leading principle in the treatment should be, from the very beginning, to convert the compound into a simple fracture, and thus protect the patient against the disastrous consequences of traumatic infection, exhausting suppuration, pyæmia, and septicæmia.

Subcutaneous or simple fractures are again divided into those which involve the floor and those which involve the rim of the acetabulum. This division rests on clinical experience as well as on the results of experimental research. Fractures of the base or floor of the acetabulum, notwithstanding their rare occurrence, yet present a great diversity in the direction and extent of the line of fracture. Courant observed a fracture which traversed the ilio-pectineal tubercle, the entire acetabulum, and the ischium. Earle and Travers describe two cases where two lines of fracture passed through the acetabulum; Neill and Sansom saw cases with three lines of fracture which extended beyond the rim. In Dr. Neill's specimen the lines of fracture followed those of the embryonal division of the bone; the union which followed was complete, and there was very little callus on the articular surface, a circumstance undoubtedly due to the slight displacement of the

fragments. More serious to the life of the patient and the future utility of the limb are those cases where a multiple fracture at the base exists with such wide separation between the fragments as to allow the head of the femur to be driven into the pelvis by the fracturing force, thereby producing an intrapelvic dislocation of the thigh. A number of such cases have been reported. Astley Cooper alludes to three cases. In two of these the thigh was rotated inward, in the third case the leg and thigh were supinated. Mr. Moore's case demonstrates the possibility and manner of repair in these cases ("Medico-Chir. Transactions," vol. xxxiv., p. 107). A man suffered a severe injury of the hip, which was diagnosticated and treated for fracture of the femoral neck. The thigh was not inverted or everted, only slightly flexed and adducted. The man recovered, and several years afterward died from other causes, when an autopsy revealed that the injury had been a fracture of the pubes, ilium, and acetabulum, which allowed the head of the femur to pass through into the pelvis, the trochanter resting against the acetabulum. Similar cases have been reported by Kendrick and Morel-Lavellée. In all cases of fracture at the base of the acetabulum, without displacement of the head of the femur, the diagnosis usually remains doubtful. Main reliance must be placed on the manner in which the injury was inflicted, the intensity of the force applied, and the location of the pain. Accurate measurement will always furnish important negative evidence. In case of intrapelvic dislocation of the head of the femur through the fractured base of the acetabulum, the shortening of the limb, and the approximation of the trochanter major toward the pelvis will be proportionate to the degree of penetration of the head and neck into the pelvis; rotation of the limb will not be practicable; flexion and extension will be found to be either impaired or rendered impossible; and at the same time the head of the femur may be felt within the pelvis on making a digital examination through the rectum. In the adoption of therapeutic measures it is necessary to ascertain the degree of impairment of the functional capacity of the acetabulum. If the head of the femur is retained firmly in its normal position the fracture will unite promptly and firmly without any special retentive measures. Rest in bed with the thigh slightly flexed and resting upon pillows will be sufficient to fulfil the local indications. If the pelvic ring is more extensively fractured, a plaster-of-Paris splint including the pelvis, both thighs, and the entire leg on the affected side, or Verity's suspension splint, will prove most efficient in securing immobility of the fragments, and will afford the greatest amount of comfort to the patient. When the base of the acetabulum has been perforated by the head of the femur it is of paramount importance to replace the dislocated bone and retain it *in situ* by a plaster-of-Paris dressing, or by applying extension by weight and pulley, as advised by Hueter, until the opening is closed by callus or connective tissue which will definitely prevent redislocation.

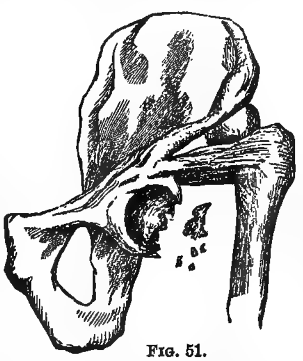

Fig. 51.

Fracture of the Rim of the Acetabulum.—A number of well-authenticated cases of this accident have been reported, so that no further doubt can exist that some portions of the rim can be fractured without further injury to the acetabulum. Some years ago the writer collected from various sources twenty-seven cases of this kind of fracture, the cases being supported by an accurate clinical history, and in some cases verified by a post-mortem examination. Dr. H. O. Walker, of Detroit, has in his possession a typical specimen of this kind, an illustration of which is here inserted (Detroit *Lancet*, July, 1879). In the text-books on Surgery this subject is usually referred to under the head of complicated dislocations of the head of the femur. As this fracture usually involves the upper and posterior portion of the rim, the resistance to the head of the femur in that direction is lost, and as a result—either with the concurrent aid of some extraneous force, or even without such aid, simply by the force of muscular contraction—a dorsal dislocation of the thigh takes place, with adduction, flexion, and rotation of the thigh inward. The difficulty experienced in retaining the head of the femur in the acetabulum under these circumstances, as well as the obscurity of the diagnosis, imparts to this subject an unusual amount of interest. The older works on surgery mention direct and great violence as the only cause of fracture of the acetabulum; indeed, until more recently, it has been considered impossible for a fracture of the rim to take place without more extensive injury to the ilium. When the fracturing force is applied over the centre of the trochanter major, in the direction of the neck of the femur, the head of the bone is driven directly against the socket, and a stellate or perforating fracture of the base of the acetabulum is the result, according to the amount of violence applied; but if the force is applied in such a manner that it first rotates the femur outward or inward, then one margin of the acetabulum acts as a fulcrum to the neck, and the head is forced against the opposite side, and a linear fracture through the acetabulum, or a fracture of the rim, takes place. In such cases, the traction of the capsular ligament assists the head of the femur in producing the fracture of the rim, but independent of other causes such traction is insufficient to produce the injury. When the force is applied to the posterior part of the pelvis, the pelvis becomes the movable point, and the foot, if the leg is extended, or more frequently the knee, becomes the fixed point, and furnishes the necessary amount of resistance. These assertions have been verified by the writer by numerous experiments on the cadaver. At the moment the injury is received, it is essential for the thigh to be *abducted*, as adduction would favor a dislocation by the head of the femur gliding over the inclined plane of the internal surface of the acetabulum. The pelvis may be the fixed point, and the force may be transmitted through the femur by a blow or fall upon the knee. In most instances where this accident occurred, the thigh was more or less flexed at the time of injury; hence, in the majority of cases, the upper and posterior segment of the rim was fractured, and the head of the femur dislocated into the upper sciatic notch or upon the dorsum ilii. Of the twenty-seven cases of fracture of the rim of the acetabulum, the extremes of the ages were eighteen and seventy-eight years, so that most of these cases occurred during the time of life when the individual is most exposed to grave injuries. It is also well to remember that, in young persons, dislocation and diastasis occur in preference to fracture, while in the aged, the altered position of the neck of the femur, as well as the increased fragility of its tissue, is a potent predisposing cause of fracture of the femoral neck.

The symptoms presented by a case of fracture of the rim of the acetabulum are those of dislocation and fracture combined; the symptoms of the former resemble ordinary dislocation, while those of the latter are directly referable to the broken bone itself. A certain degree of displacement of the head of the femur was present in all cases where a diagnosis was made during life. Benjamin Travers believed that in some cases of fracture of the rim of the acetabulum the displacement takes place gradually some time after the injury has been received, but it is more probable that these were cases such as have been described by Hueter as inflammatory dilatation of the acetabulum, the interstitial absorption of the margin of the cavity permitting the head of the femur to glide upward and backward. In twenty-four cases the direction of the dislocation is mentioned, and in fifteen of these the head of the femur was dislocated upward and backward, in four into the great sciatic notch, in two directly backward, in two downward, and in one case forward. It will be seen, then, that in a large majority of cases that portion of the rim is fractured which is in the direction of the usual form of dislocation, so that the same injury which pro-

duces a dislocation may also cause a fracture, provided the force applied be sufficiently great, and the limb happen to be abducted at the time the injury is sustained.

The amount of shortening corresponds to the distance the head of the femur recedes from the socket. In Agnew's case no shortening could be detected on careful measurement. In all of the other cases where mention is made of this symptom, it was present, but varied in degree from a quarter of an inch to four inches. If the head of the femur has left the socket the position of the limb is the same as in simple dislocation, the direction being determined by the form of dislocation. Flexion to a greater or less extent was present in all cases where reference is made to this subject. Inversion of the foot and rotation of the femur inward were present in fourteen cases, while the opposite condition existed in three cases, and in ten cases no mention is made of this symptom. When the dislocation was complete, the limb remained immovable in its abnormal position until reduction was effected. The characteristic symptoms of the injury are those which are referable to the fracture itself, and these are crepitus, easy reduction, and difficult retention. Crepitus is always an important symptom in ascertaining the existence of a fracture. If it is distinctly felt there can be no further doubt that a bone has been broken. The presence of this symptom is of special diagnostic value in connection with this subject, as the symptoms of dislocation are usually so prominent as to engage the whole attention of the surgeon. In the cases reported, this symptom is alluded to eighteen times, and in the following terms; distinct, eleven times; faint, once; marked, twice; indistinct, once; slight, once; and in two cases it was absent. Bigelow lays great stress on this symptom as being essential to the diagnosis of fracture; his words, as quoted from the work previously mentioned, are: "To afford satisfactory evidence, cases of this sort should have been identified by autopsy, or at least by crepitus." I believe that the crepitus is not the same as in ordinary fractures, for in these it is the result of two rough bony fragments rubbing against each other, while in the cases under consideration it is a roughness we obtain by rubbing an articular surface against a broken surface of bone, hence not quite as loud and distinct. The detached margin of the acetabulum, unless comminuted, remains attached to the capsular ligament, and is pushed in front of or to one side of the head of the femur at the time dislocation occurs, and is dragged after it when reduction takes place. In most of these cases it is clearly stated that crepitus was felt just before the head of the femur slipped into the socket, or at the moment reluxation took place, and in both instances it must have been produced by the head passing over the rough broken edge of the acetabulum. The ease with which reduction has been effected has attracted the attention of almost every observer. This is due to a more extensive laceration of the capsular ligament than in simple dislocation, and also to the removal of the obstacle offered by the intact margin of the acetabulum. By the fracture of the rim, a more direct and even route has been prepared for the head of the femur to return to its socket.

Reluxation has always constituted the most perplexing feature of these cases. Its occurrence has usually led to a more thorough examination and correct diagnosis. It is well known that in ordinary dislocations of the hip-joint, when the bone has once been reduced, it remains in its place regardless of the after-treatment, differing greatly in this respect from the same lesion of the shoulder-joint on account of the greater depth of the socket, and the action of more numerous and powerful muscles for maintaining retention. Hueter believed that the cases of habitual dislocation of the hip-joint reported by Karpinski may have been the result of injury to the rim of the acetabulum. Reluxation takes place from the inability of the defective margin to resist muscular contraction. The difficulty in retaining the bone is increased by the depth of the fracture and its approach to the junction of the superior and posterior portions of the rim. In this connection it is important to determine what portion of the rim is most frequently the seat of the fracture. In 20 of the cases special mention is made of this fact, as follows: superior portion of rim, 2; superior and posterior, 7; posterior, 5; posterior inferior, 4; inferior, 1; anterior, 1. When the inferior or anterior portion of the rim is fractured, there is no tendency to reluxation provided the limb is kept in the extended position and slightly inverted.

Diagnosis.—A most thorough and critical examination while the patient is profoundly under the influence of an anæsthetic, is always necessary to establish a positive diagnosis. If spontaneous reluxation does not follow immediately after reduction has been accomplished, and there are sufficient symptoms present to warrant a suspicion of the presence of the injury, it would be advisable to test the functional integrity of the acetabulum by flexion, adduction, and rotation of the thigh; if any part of the rim has become defective by fracture, reluxation will be sure to take place. This manœuvre, associated with the presence of crepitus, may be regarded as the crucial test.

The differential diagnosis must consider fractures of the neck of the femur with displacement, and simple dislocation. To distinguish this fracture from fracture of the neck of the femur, it is necessary to compare their most prominent symptoms:

FRACTURE OF THE RIM OF THE ACETABULUM.	FRACTURE OF THE NECK OF THE FEMUR WITHOUT IMPACTION.
Position of Limb.	
Thigh and leg flexed, adducted, and rotated inward.	Thigh and leg straight and rotated outward.
Mobility of Limb.	
Mobility of limb is diminished.	Mobility of limb is increased.
Arc of Rotation.	
The trochanter major rotates in its normal arc.	The arc of rotation of the trochanter major is diminished.
Crepitus.	
Crepitation is not rough, and is felt as the head passes over the broken edge of the acetabulum.	Crepitation is rough, and is felt when the limb has been drawn down to its normal length.
Head of the Femur.	
The head of the femur is felt to be displaced.	The head of the femur is normal in its position.
Retention.	
The deformity reappears if by any movement of the limb the head of the femur is made to leave the socket.	The deformity reappears as soon as extension ceases.
History.	
Is most frequent in middle life and is the result of great violence.	If intra-capsular in variety, it occurs in the aged and is the result of slight violence.

Crepitus, and a tendency to reluxation, are the symptoms on which we place the most reliance to differentiate this fracture from simple dislocation. Acupuncture, as advised by Middeldorpf, may be of great service to determine the existence of fracture of the rim. After reduction has been accomplished, a long stout needle, previously well disinfected, is passed through the tissues to the supposed seat of fracture. By lateral movements of its point the defect in the margin, as well as the roughness of its surface, is ascertained. An effort should now be made to fix the detached fragment with the point of the needle, and by rubbing it over the broken margin a rough crepitus is elicited.

Prognosis.—The prognosis must have reference to the preservation of life and the restoration of the utility of the limb. All of the old authors regarded fracture of the pelvic bones a grave lesion, almost necessarily leading to a fatal termination. I believe that all uncomplicated fractures of these bones tend to recovery, and that death is attributable in most instances to a lesion of some important pelvic or abdominal viscera. In twenty-three cases where the result is noted in this regard, thirteen recovered and ten died. The prognosis is less favorable if the floor of the acetabulum is also implicated in the fracture. Of four cases of this sort only one recovered. In nine cases out of the thirteen that recovered, the limb remained in place after reduction, and the recovery was complete. In four cases redislocation took place, the limb assuming the same malposition as after simple unreduced dorsal dislocation of the femur.

Treatment.—The indications to be fulfilled in the treatment of this class of injuries are : 1, To reduce the dislocation ; 2, to retain the head of the femur in the socket until union has taken place between the fragments. The dislocation may be reduced by manipulation or by extension ; in both instances flexion constitutes an important step in the operation. Bigelow says : "These displacements, especially the displacement backward, demand the usual attempts at reduction by flexion. Although the bone inclines to slip from the socket it can be retained there, in cases of a sort heretofore considered difficult of treatment, by angular extension, with an angular splint attached to the ceiling, or some other point above the patient ; or if any manœuvre has reduced the bone, the limb should be retained, if possible, in the attitude which completed the manœuvre." In 17 of the cases reported, the manner of reduction is specified as follows : By extension, 11 (in most of these cases extension and flexion were combined) ; by manipulation, 2 ; by manipulation and extension, 1 ; by manipulation over Sutton's fulcrum, 1 ; by extension with pulley, 2. In all but one of the cases the displacement was corrected without difficulty. As in most instances a diagnosis cannot be made before reduction has been accomplished, surgeons will resort to their favorite methods of reduction. Should the nature of the lesion be determined beforehand, traction in the direction of the broken edge of the rim, and rotation of the limb inward, will readily restore the normal relation of the parts. As we possess no direct measures of keeping the fractured surfaces in apposition, all our efforts must be directed toward preventing reluxation by appropriate position and fixation of the limb and pelvis. The depth and extent of the fractured margin, as well as the location of the fracture will determine the difficulty in retaining the head of the femur in its normal position. If sufficient depth of the upper portion of the rim is left to serve as support to the head of the bone, all that is necessary is to dress the thigh in the abducted position, so as to press the head of the femur against the floor of the acetabulum. As the contusions of the soft parts about the hip and pelvis are severe, a plaster-of-Paris splint cannot be applied as a primary dressing. The healthy limb and pelvis should always be included in the retentive dressing. Bonnet's wire-breeches, Dzondi-Hagedorn's apparatus, or Hamilton's splint, as advised by him in the treatment of fractures of the femur in children, will be found sufficient to maintain retention. After the swelling in the soft parts has subsided, nothing more perfect could be devised than a plaster-of-Paris dressing, including both limbs and the pelvis.

When nearly the entire depth of the upper or posterior portion of the rim has been detached, muscular contraction must be counteracted by permanent extension with the weight and pulley, and immobility of the joint should be secured by appropriate splints. In cases of this sort, angular extension with an angular splint, as advised by Bigelow, will answer an admirable purpose. The unbroken part of the rim should be made the support of the head whenever practicable. Thus, for example, when the posterior part of the rim is fractured the thigh should be dressed in the position of hyperextension ; a broad, firm, pelvic band, with a compress above the trochanter, being employed to aid in keeping the bone in place, in approximating the fractured surfaces, and in preventing muscular spasms.

The treatment should be continued for a sufficient length of time to secure a firm union of the detached fragment with the broken rim, which, as in other fractures, generally requires from four to six weeks. The patient must be directed to exercise great care in the use of the limb for a considerable length of time after all dressings have been removed, so as to obviate any undue pressure against the recently repaired rim of the acetabulum.

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N. Senn.

ACETIC ACID. Acetic acid, $HC_2H_3O_2$, the well-known acid of vinegar, is a body fluid at ordinary temperatures, and miscible in all proportions with water. Mixtures of the acid and water in different proportions constitute the different grades of the acid in commerce. Strong acetic acid is caustic, largely through its property of dissolving the formed material of the connective tissues to a pultaceous translucent substance. Being caustic, it is of course irritant, and swallowed in concentrated condition operates as a corrosive poison, the effects and symptoms being substantially the same as in poisoning by the strong mineral acids. Two cases of death have been recorded. The treatment is similar to that to be employed in case of poisoning by a mineral acid. In non-corrosive strength of solution (five or six per cent., the equivalent of vinegar), acetic acid produces the usual local effects of the sour acids—exciting the flow of saliva and tending to oppose sour fermentation of the food, and is also distinctly astringent. Inhaled, the fumes are reviving in faintness and may relieve headache.

Acetic acid has many uses in pharmacy ; in medicine the strong acid may be employed as a caustic, as to warts or cancers, and the weak acid used to make refreshing acid draughts in fever, or cooling lotions in inflammatory skin affections. Acetic acid is officinal in the U. S. Pharmacopœia in the following forms :

Acidum Aceticum Glaciale, Glacial Acetic Acid.—This is defined to be "nearly or quite absolute acetic acid." It is "at or below 15° C. (59° F.) a crystalline solid ; at higher temperatures a colorless liquid. When liquefied and as near as possible to 15° C. (59° F.) it has the specific gravity 1.056 to 1.058" (U. S. Ph.). According to Squibb (*Ephemeris*), the specific gravities thus stated are from 0.0001 to 0.0002 too high. This grade of the acid is for pharmaceutical uses.

Acidum Aceticum, Acetic Acid. — The grade of acid thus simply named is a "liquid composed of thirty-six per cent. of absolute acetic acid and sixty-four per cent. of water." It is "a clear, colorless liquid, of a distinctly vinegar-like odor, a purely acid taste, and a strongly acid reaction. Specific gravity, 1.048 at 15° C. (59° F.) Miscible in all proportions with water and alcohol, and wholly volatilized by heat" (U. S. Ph.). This grade of acid is somewhat stronger than the best samples of the commercial so-called "No. 8" acid, these "No. 8" acids rarely being of higher specific gravity than 1.030 and often sinking to 1.025 or less (Squibb). This is the acid that results from the purification of the crude acid—*crude pyroligneous acid,* so called—obtained by the destructive distillation of wood.

Acetic acid of the present quality is sharply irritant and even mildly caustic. Dangerous symptoms have resulted from swallowing it, undiluted, in quantity of two or three ounces. The acid may be used as a mild caustic, but its principal uses under its own form are pharmaceutical.

Acidum Aceticum Dilutum, Diluted Acetic Acid. — This preparation is compounded of seventeen parts of acetic acid of the foregoing grade and eighty-three parts of water. It "contains six per cent. of absolute acetic acid, and has the specific gravity 1.0083" (U. S. Ph.). This diluted acid is of the strength of the best qualities of vinegar, and is better than vinegar for all the purposes of the same, medicinal or dietetic. Squibb says, "If one part of alcohol be added to about two hundred and fifty-six parts of this diluted acetic acid—that is,

about half a fluidounce to the gallon, and the mixture be set aside for a few weeks—the longer the better, enough acetic ether is generated to give it the full, clean aroma of fine vinegar, and then for table use it is very far superior to any vinegar made in the ordinary way by fermenting cider."

Diluted acetic acid is the most convenient grade of the acid for medicinal use, and has also, in the U. S. Pharmacopœia, superseded vinegar for pharmaceutical purposes. For an acid draught a five per cent. addition to water is appropriate, and for a lotion a twenty-five per cent. addition. The popular notion that the habitual use of vinegar tends to deterioration of nutrition and health is certainly not true of a moderate indulgence, if indeed it be true at all. *Edward Curtis.*

ACETIC ETHER. Under the title *Æther Aceticus*, Acetic Ether, the U. S. Pharmacopœia makes officinal a preparation consisting of the ethereal salt, *ethylic acetate*, with a little contaminating alcohol and water. Acetic ether is described as "a transparent and colorless liquid, of a strong, fragrant, ethereal, and somewhat acetous odor, a refreshing taste, and neutral reaction. Soluble, in all proportions, in alcohol, ether, and chloroform, and in about seventeen parts of water. Specific gravity, 0.889 to 0.897. It boils at about 76° C. (168.8° F.). It is inflammable, burning with a bluish yellow flame and acetous odor" (U. S. Ph.). It should be kept in well-stopped bottles, and away from lights or fire. Dr. Squibb notes, concerning the foregoing description, that while the *odor* is "refreshing," the *taste* is rather "pungent and biting almost to acridity;" and that the solubility in water is nearer one part in 11.86 than one in 17; and that few of the commercial samples of acetic ether will reach the officinal range of specific gravity.

The effects of acetic ether upon the animal economy are similar, in a general way, to those of common ether, the most important point of difference being that acetic ether is the slower in operation. For this reason this ether is not available as a surgical anæsthetic; but, on the other hand, by reason of its agreeable odor, it makes an excellent and grateful cardiac stimulant, antispasmodic and carminative, taken internally, or, used externally, it may serve to mask disagreeable odors. It may be given internally, in quantities ranging from fifteen to thirty drops, well diluted with water or with some medicinal preparation, to which the ether is added as an adjuvant or corrigent. Acetic ether enters into the composition of the officinal preparations, *perfumed spirit* (cologne water), and *tincture of acetate of iron.* *Edward Curtis.*

ACETONÆMIA. This term is used by many writers to express a diseased condition of the blood, due to the supposed presence in it of acetone, or of some of its derivatives. This state of the blood, according to their views, accounts for the nervous symptoms peculiar, more especially, to diabetic coma. It is believed to be the cause, also, of somewhat similar symptoms occasionally present in certain anæmic conditions of the blood, such as pernicious anæmia, and that associated with some of the more rapidly wasting forms of cancer, as cancer of the stomach.

Petters first observed the acetone-like smell of the urine in a case of diabetic coma. He drew attention to the subject in 1857, and supposed it to be due to the presence of acetone in the blood. Since then Kussmaul has paid more attention to the subject, and has endeavored to account for the sudden death in these cases by the rapid accumulation of this substance in the blood. He considers it a species of intoxication produced by the acetone. Numerous experiments on animals have been made by him, which seem to confirm his view of the subject. Dogs, to which he administered acetone hypodermically, as well as by inhalation, presented some of the nervous symptoms in connection with respiration, circulation, and locomotion that seemed to support his views. Frerichs decidedly objects to this theory of the causation of the comatose symptoms of these cases of diabetes. He thinks the term acetonæmia should be expunged from pathology (*Zeitschr. f. klinisch. Med.*, vi., 28). His experiments do not bear out Kussmaul's conclusions. He administered acetone in doses varying from ten or twelve to twenty grains, to both man and animals, without producing any nervous symptoms at all similar to those observed in diabetic patients. He considers it quite a mistake to attribute the nervous symptoms of diabetic intoxication to the presence of either acetone or its derivatives.

Kussmaul has still numerous supporters of his views. In the cases described, the breath has been observed to possess a fruity odor, resembling apples; or, as described by some, an odor similar to chloroform. The mucous membrane of the mouth and throat has a dry and glazed appearance, and is generally very red. The urine also possesses a similar odor. (See Acetonuria.)

Von Jaksch asserts that acetone occurs, to a slight extent, as a normal product in the blood as well as in the urine (*Zeitschr. f. klin. Med.*, v., 347).

It is doubtful if free acetone can be obtained from the blood; nevertheless, in many cases of diabetic coma, a substance with which acetone is combined can be obtained from it, and free acetone derived from this. There is yet some doubt as to what this body is. Some investigators are inclined to consider it to be ethyl-diacetate, while more recent authorities believe aceto-acetic acid to be the substance. There seems to be very good ground for thinking this to exist in the blood, as we know it to be one of the products of alcoholic fermentation of glucose. *George Wilkins.*

ACETONE. Acetone, C_3H_6O, the ketone of acetic acid, called also *pyroacetic spirit* and *pyroacetic ether*, is a colorless, limpid, and inflammable liquid of pungent quality, miscible in all proportions with water, alcohol, and ether. Its effects upon the animal system are, doubtless, of the general nature of those of the volatile alcohols and ethers, but the substance has never been systematically employed as a medicine. *Edward Curtis.*

ACETONURIA. According to Von Jaksch, acetone enters into the composition of every normal urine, to the extent of about one centigramme per day. When the quantity exceeds this amount, the pathological condition of acetonuria is present. In continued fevers, with high temperature, the quantity secreted has been found as high as five decigrammes. In these cases, it is only after the fever has lasted a considerable time that acetone has been found in the urine.

There are four principal diseased conditions in which it exists. These are, first, in fever of any kind, especially if the fever rises high and the febrile condition lasts a long time; second, in diabetes; third, in cancer; fourth, in acetonæmia.

Observers are not yet quite agreed as to what the substance is that is found in the blood as well as in the urine in these cases; for, while some believe it to be acetone, others are of the opinion that it is a body such as aceto-acetic acid or ethyl-diacetate, from which acetone can be obtained. Acetone gives to the urine a peculiar odor, described by some as resembling chloroform, by others as of a more fruity character, such as that of apples, or, again, like that of hot vinegar.

Frerichs and others have experimented with acetone, both on man and the lower animals, administering it in doses as large as twenty grains, and have so far found it harmless, although traces of it have been obtained from the urine in these cases. Diabetic urine containing acetone gives a deep red or reddish-brown color in the presence of perchloride of iron[1] (Gerhardt's test), and a rose-tint in the presence of sulphuric acid. For the former test, take a few cubic centimetres of the urine supposed to contain acetone; add to it one or two drops of liq. ferri perchlorid.; this gives a grayish-white precipitate; the addition of a few drops more of the solution of iron in excess causes the precipitate to disappear if acetone is present, and gives a beautiful reddish-brown, which is not produced in normal urine.

The sulphuric-acid test is performed by adding a few drops of the acid to the urine containing acetone, when a

beautiful rose color is produced; on subsequently adding a few drops of perchloride of iron, this rose tint is converted into a yellowish orange, which is characteristic.

The peculiar reaction with perchloride of iron has been obtained from the urine of other diseases than diabetes. Various observers have obtained it in typhus, pneumonia, diphtheria, perityphlitis, pleurisy, and acute rheumatism.

The diabetic cases in which but a small amount of acetone is present in the urine are usually very slight. In many of these cases, Gerhardt's reaction (the burgundy red with perchloride of iron) cannot be obtained. On the other hand, the cases in which it is present are usually very severe, and frequently die with comatose symptoms.

Treating distilled urine with a solution of iodine in iodide of potassium and caustic soda causes the yellow precipitate of iodoform, if acetone is present. This is known as Lieben's test. Penzoldt recommends a test known as his *indigo test.* It depends upon the fact that acetone, in the presence of an alkali, changes orthonitrobenzaldehyde into indigo. Caustic alkali is to be added to the suspected urine, so as to render it distinctly alkaline. A watery solution of orthonitrobenzaldehyde is to be prepared and the alkaline urine to be added to this. If acetone is present, a yellow color is produced, which changes immediately to green, and in about ten minutes assumes an indigo color.

Other tests are Legal's and Le Nobel's. The former is the addition of cyanide of potassium and a few drops of a concentrated solution of caustic soda or potash to the suspected urine; this produces a dark-red color, which changes to yellow after a few minutes; if acetic acid is now added, the solution changes to carmine-red if only a small quantity of acetone is present, to a purple-red color if a large quantity is present; after two or three hours this changes again to a brownish-green. Le Nobel's test depends upon the fact that substances containing acetone become of a violet-red upon the addition of cyanide of sodium with ammonia or its bicarbonate.

George Wilkins.

[1] This color is frequently referred to by foreign writers as "burgundy red," from its resemblance to that of the wine of that name.

ACIDITY, literally the quality of being sour, is a term used in medicine to denote either (1) a quality of the normally acid fluids of the body; (2) a change in their character or amount; or (3) the alteration of a normally alkaline to that of an acid secretion. It may, then, be either physiological or pathological.

PHYSIOLOGICAL ACIDITY. — We have several well-marked instances of the former, *e.g.*, in the gastric juice, the urine, the cutaneous excretions, and in the secretions of the muciparous crypts of the mouth and vagina.

The gastric acidity, in health, is due, so far as is at present known, to the secretion of lactic acid (Query: from the small but constant quantity of glycogen in the blood?) by the gastric follicles; which, reacting upon the sodic chloride (NaCl) also present, produces free hydrochloric (HCl) acid. The acidity of this secretion varies between 0.01 to 0.32 per cent., the average being 0.17 per cent.

The normal *acidity of the urine* is due indirectly to the uric acid excreted. Reacting upon the mildly alkaline sodic phosphate of the blood it abstracts part of the sodium, leaving the acid sodium phosphate, viz.:

$$\underset{\text{Uric Acid}}{H_2C_5H_2N_4O_3} + \underset{\text{Disodic Hydric Phosphate}}{Na_2HPO_4} = \underset{\text{Sodic Hydric Urate}}{HNaC_5H_2N_4O_3} + \underset{\text{Acid Sodic Phosphate.}}{NaH_2PO_4}$$

This gives urine its acid reaction; the degree varying within quite a wide range. Variations in health bear an intimate relation to the digestive process and the foods taken. Generally speaking, an hour after meals the acidity is least, due to the organic potassium and sodium salts taken in the food having been converted in the blood into the alkaline bicarbonates. Gradually increasing in acidity, it reaches a maximum after two and a half to four hours; this gain being caused by the oxidation products (uric acid, etc.) of the proteids and nitrogenous tissues, occasionally, too, by such organic acids as oxalic and hippuric, the latter formed from benzoic acid, and often present in fruits (cranberries).

The normal *acidity of the cutaneous excretions* is owing to the presence of some of the fatty acids of the acetic series, chiefly capric and caproic acids. The acids of the buccal and vaginal mucous crypts are unknown.

PATHOLOGICAL ACIDITY.—Pathological changes in the acidities of the various body fluids may be of degree or of kind.

The blood during life is ALWAYS alkaline, no investigators having ever found it otherwise. (See Art. Alkalinity.) Its degree of alkalinity may vary. To speak of "acidity of the blood," then, is an erroneous expression, but one not infrequently applied to a greatly diminished alkalinity. The oxidation products of the foods and tissues form the principal source of the acids in the system; though some, it is true, are supplied, often intentionally, with the foods. Their representatives are lactic, uric, and oxalic acids. Since the liquor sanguinis is always alkaline, they cannot exist in it in the free state. They must, therefore, remain where they were formed (either in the cells or between them), external to the capillaries, until they can have received either sufficient alkaline bases to neutralize them or oxygen to destroy them, or both. Thus we have, after muscular exercise, free lactic acid in the muscle-juices; but, after rest for some time, it disappears. It has been repeatedly shown that about 890 grms. (28 oz.) of carbonic acid through the lungs, and acid matter equal to 2 grms. (31 grs.) of oxalic acid through the kidneys, are daily excreted. When undergoing oxidation in the system, complex organic substances are not changed to their lowest oxidation products at one step, but by gradual transitions, each time to simpler substances, thus affording a gradual liberation of vital energy.

So glycogen changes into lactic, then oxalic, and finally carbonic acids. The various acid products are easily, in health, converted by the ozone of the blood into CO_2—H_2O—NH_3—and urea, all readily excreted. Inefficient oxidation would increase the intermediate products, which are chiefly acids.

The degree of alkalinity of the blood, therefore, depends upon (1) the amount of acids formed; (2) the amount of oxidizable matter furnished; and (3) the rate of elimination.

(1.) The amount of acids formed will be increased by interference with the assimilation of oxygen, because complete oxidation cannot well occur; and the intermediate acid products will result. This interference may be of a mechanical or a pathological character. We may class tumors of the thorax or abdomen and ascites with the former; leucocythæmia, anæmia, chlorosis (diseased oxygen carriers), or heart and lung diseases with the latter class of causes.

(2.) Excess of oxidizable matter with normal oxygen supply will cause increased acid products. Here the oxygen is not diminished, but the matter to be oxidized, being in excess, finds insufficient oxygen for complete combustion. Such an increase occurs in that class of so-called "gouty" patients who, leading a very sedentary life, consume large quantities of rich animal and vegetable food; or again, in the acute febrile processes, where the body tissues, having, seemingly, lost their power of resistance, fall a prey to the insatiable oxygen.

(3.) Interference with elimination will, naturally, cause an accumulation in the system of acid products that may diminish the alkalinity of the blood to an extent sufficient to cause death. Diseased conditions of the emunctories, particularly the kidneys and skin, are frequent causes, but inattention to hygienic conditions and lack of exercise, without diseased conditions, may do the same. In severe cases of interference with elimination, uric acid has been found in the nasal, pharyngeal, gastric, vaginal, cutaneous secretions (Boucheron), and in the menstrual blood; also in the saliva in all forms of uricæmia.

Under any of those conditions in which the alkalinity of the blood has been reduced to a minimum, even the alkaline secretions, by a sort of vicarious action, eliminate some of the acid products; and this continuing for some time, will induce a catarrhal inflammation. Thus a bronchial, intestinal, or genito-urinary catarrh, is not infrequently caused.

"Acidity of the stomach," a term rather loosely used to denote heartburn, pyrosis, acid dyspepsia, etc., may be dependent upon several causes. The normal acidity of the stomach, ranging between 0.10 per cent. to 0.32 per cent., and averaging 0.17 per cent., may be increased or diminished. The majority of cases of "acidity of stomach" belong to the former, where a greater amount of acid is secreted than is needed for the purposes of digestion. In a fewer number of cases a diminished flow occurs (0.01 per cent.). Here the foods not protected by the antifermentative action of the gastric juice undergo one of the various acid fermentations (*e.g.*, lactic, butyric, or acetic), thus giving rise to the same phenomena as in excessive flow. Reichmann has recently furnished an interesting explanation of the subjective symptoms developed in acidity. His conclusion, based upon carefully conducted experiments with such cases, as compared with similar experiments upon the healthy adult, is, that the peculiar burning pain, with sensations of oppression, weight, etc., is *always* the result of regurgitated normally (or abnormally) acid gastric fluids into the lower extremity of the œsophagus. Here the normal secretion is alkaline. It has been shown that irritation of the gastric mucous membrane from any cause induces, by a reflex action transmitted through the vagus to its branch (the nervus dilator cardiæ recently demonstrated by Openchowski), an active dilatation of the cardiac orifice, thus permitting a partial regurgitation of the acid fluids. By an ingenious method he found the reaction always acid here, when the patients complained of the above symptoms, while in other cases it was alkaline. Now, the irritant which produces this dilatation permitting regurgitation is most frequently that arising from too acid secretions acting on the membrana mucosa; but it should be borne distinctly in mind, for purposes of diagnosis, that any other irritant might occasion the same phenomena without an increased acidity. Such we see exampled frequently in those who drink irritating liquors, and eat hot sauces with their highly spiced foods; or characteristically in the "sour stomach" of the beer drinker, where the gastric acidity has been demonstrated as reduced to a minimum (0.01 per cent.). Nor is the gastric juice abnormally acid when from the irritation of small gastric ulcers all the signs of so-called acidity arise.

In the conditions described as existing in so-called "acidity of the blood," the amount of acid matter excreted by the kidneys is greatly increased, particularly the uric acid. When a slightly larger quantity of uric acid is excreted than can be neutralized by the replaceable sodium in the sodic phosphate, the excess remains free and uncombined in the urine, which, the condition enduring, will often induce a catarrhal inflammation of the mucous membranes with which it comes in contact. Should the uric acid be in still greater quantity, it, being very insoluble (1 to 15,000), may be precipitated in any part of the urinary tract, or after emission in the cooled urine. Thus originate the uric acid calculi of the kidney and bladder.

The normal cutaneous excretions contain some of the volatile fatty acids (chiefly capric), which, under certain conditions or idiosyncrasies not well understood, are greatly increased. To this condition the term bromidrosis has been applied. When the skin endeavors to eliminate the excess of acids from the blood, not infrequently an urticaria, herpes, or eczema arises, subsiding as soon as the normal alkalinity of the blood is reached. For quantitative estimation of acid excreta in urine—an index to the proportion of acids in the system—see Art. Urine.

THERAPY.—The existing conditions being known, the indications are evident. If the difficulty lies in faulty oxidation, then means should be directed to its improvement. Such are increased exercise, ferruginous tonics, simple foods in moderate quantity, and especially an increase of the alkalinity of the blood, because it is a physiological fact that "oxidation occurs easiest in alkaline media." (See Art. Alkalinity.) The idea, then, is not simply to neutralize, but to destroy the acid products. This can be accomplished by the use of either the alkaline salts of potassium, sodium, or lithium (*e.g.*, their carbonates), or, better, by the employment of the neutral salts of those bases with the (easily oxidizable) organic acids, such as acetic, citric, or tartaric acid. These are preferable, because entering the circulation without neutralizing the gastric acids and impairing digestion, they are soon converted into the bicarbonates by oxidation, when they will neutralize any acids present in the economy. All the vegetable acids entering the circulation, combined with the alkaline bases, are completely destroyed, appearing in the excreta as carbonates; but if taken in the free state (in quantity) they are excreted wholly or in part unchanged. Liebig's explanation is that the alkalinity of the blood is so greatly reduced by their absorption that oxidation cannot well take place, and they are excreted as salts. Thus the existence of gallic acid in alkaline media with oxygen is impossible. Where an immediate effect is desired, two or three large doses, 1 to 3 grms. (grs. 15 to 45), of the bicarbonates (preferably sodium), given in considerable water at short intervals, will accomplish the desired result. Thus an urticaria caused by acid excretions through the skin may oftentimes be relieved. If the "acidity" be through faulty elimination, the good sense of the physician will dictate appropriate remedies. The urate of lithium, being far more soluble than either the potassium or sodium salts, the carbonate of this base would form a more scientific remedy in cases of the so-called "uric acid diathesis."

Lewis L. McArthur.

ACIDS. PHYSIOLOGICAL.—*Normal Butyric Acid,* C_3H_7, CO. OH, occurs principally as a glycerine ether in butter, but also in sweat. It is formed abundantly by the butyric fermentation of lactic acid,

$$2C_3H_6O_3 = C_4H_8O_2 + 2CO_2 + 2H_2,$$

and at the same time also acetic and caproic acids are formed. It may be conveniently isolated by allowing grape-sugar or cane-sugar to ferment with rotten cheese and some calcium carbonate. After standing for a considerable time, calcium butyrate is formed, which separates out on boiling, and the acid may then be set free by hydrochloric acid. Normal butyric acid, CH_3, CH_2, CH_2, CO. OH, is an oily fluid, boiling at 162.3° C. (324° F.) (Linnemann), solidifying at −19° C. (−2.2° F.), and mixing in all proportions with water. The glyceride tributyrin, $C_3H_5(C_4H_7O_2)_3$, occurs in cows' butter, but can also be made synthetically. It is a colorless neutral oil of specific gravity, 1.056 at 8° C. (46.4° F.).

Isovalerianic (*Isopropylacetic*) *Acid,* C_4H_9, CO. OH, occurs as a glyceride in the blubber oil of certain dolphins (*delphinus globiceps* and *phocœna*). It is also formed by the decomposition of albuminous bodies (casein), but is most easily prepared by the oxidation of fusel oil (amyl alcohol) by chromic and sulphuric acids.

Isovalerianic Acid, $(CH_3)_2$, CH, CH_2, CO. OH, is an oily, colorless fluid, smelling like rotten cheese. It boils at 176.3° C. (349.4° F.) (Kopp); specific gravity, 0.931 at 20° C. (68° F.), and soluble in water.

Triisovalerin, $C_3H_5(C_5H_9O_2)_3$, found in dolphin blubber, is a colorless oil, neutral, and insoluble in water.

Caproic Acid, C_5H_{11}, CO. OH, occurs as a glyceride in cows' butter; also formed, as a rule, with butyric acid in fermentation. It is an oily, colorless liquid, solidifying at −18° C. (−0.4° F.), boiling at 205° C. (401° F.); specific gravity, 0.928 at 20° C. (68° F.). Insoluble in water, with a faint, unpleasant smell. The pure glyceride has not been isolated.

Caprylic and Capric Acids.—Normal caprylic acid, C_7H_{15}, CO. OH, and normal capric acid, C_9H_{19}, CO. OH, occur in very small quantities as a glyceride in cows' butter. The first crystallizes in leaflets, melting at +16.5° C. (62° F.), boiling at 236° to 237° C. (457° to

458° F.), and of very difficult solubility, even in boiling water. Capric acid occurs in fine needles, melting at 30° C. (86° F.), boiling at 268° to 270° C. (514° to 518° F.): very insoluble in boiling water. The pure glycerides of these acids are not known.

Lauric and Myristic Acids.—Lauric acid, $C_{11}H_{23}$, CO. OH, and myristic acid, $C_{13}H_{27}$, CO. OH, are both found as cetylic ethers in spermaceti (Heintz). The first crystallizes in needles, melting at 43.6° C. (110.5° F.); the latter in leaflets, melting at 53.8° C. (129° F.).

Palmitic Acid, $C_{15}H_{31}$, CO. OH, is found in all fats, generally as a glyceride, in combination with stearic and oleic acids, sometimes as cetylic ether (spermaceti) and myricylic ether (beeswax). When pure, palmitic acid crystallizes in scales, which melt at 62° C. (143.6° F.). The glyceride, *tripalmitin,* $C_3H_5(C_{16}H_{31}O_2)_3$, is crystalline, melts at 61.5° C. (143° F.); is almost insoluble in spirit of wine, but slightly so in absolute alcohol (boiling); very easily in ether.

Cetylic Ether, $C_{16}H_{33}$, $C_{16}H_{31}O_2$, constitutes the principal part of spermaceti. It crystallizes in leaflets, and melts at 53.5° C. (128.5° F.) (Heintz).

Myricylic Ether, $C_{30}H_{61}$, $C_{16}H_{31}O_2$, forms the principal part of beeswax; is insoluble in alcohol; crystallizes in feathery aggregations, and melts at 72° C. (161.6° F.) (Brodie).

Stearic Acid, $C_{17}H_{35}$, CO. OH.—Found as a glyceride, especially in the solid fats, and may be obtained in large quantities from mutton- or beef-suet. Pure stearic acid crystallizes in leaflet, melting at 69.2° C. (156.5° F.) (Heintz); soluble with difficulty in cold spirit of wine, but easily in benzol, carbon disulphide, and ether.

The glyceride *Tristearin,* $C_3H_5(C_{18}H_{35}O_2)_3$ is found in all fats. It crystallizes in scales, glistening like mother-of-pearl. According to Heintz, it has two melting-points—first at 56° C. (132.8° F.), becoming again solid at a higher temperature, and melting again at 71.6° C (161° F.). It is easily soluble in boiling absolute alcohol and ether.

Arachic Acid, $C_{19}H_{39}$, CO. OH.—This acid is found in cows' butter as a glyceride. It crystallizes in small glistening leaflets, which melt at 75° C. (167° F.).

Triarachin, $C_3H_5(C_{20}H_{39}O_2)_3$, is granular; very slightly soluble in ether.

Medullic Acid, $C_{20}H_{41}$, CO. OH.—According to Eylerts, the glyceride of this acid is found in the spinal cord of the ox. It melts at 72.5° C. (162.5° F.).

Hyæna Acid, $C_{24}H_{49}$, CO. OH.—The glyceride of hyæna acid was found by Carius in the secretion of the anal glands of the hyæna, from which it is obtained by saponification and fractional distillation. The pure acid crystallizes in small clumps of feathery needles, melting at 77° to 78° C. (170° to 172° F.); soluble in cold absolute alcohol with difficulty, more easily in hot absolute alcohol, and very easily in ether. The pure glyceride is probably contained in hyæna fat, but has not been isolated.

Cerotic Acid, $C_{26}H_{53}$, CO. OH, is found free in beeswax. As cerylic ether it forms the principal part of Chinese wax. The free acid forms granular crystals, which melt at 78° C. (172° F.); it dissolves with difficulty in alcohol. The cerotic acid cerylic ether, $C_{27}H_{55}(C_{27}H_{53}O_2)$ is crystalline, wax-like, and melts at 82° C. (179.6° F.).

Physetoleic Acid, C_{15}, H_{29}, CO. OH, was found by Hofstädter in the oil from *physeter macrocephalus.* It melts at 30° C. (86° F.); oxidizes in the air.

Oleic Acid, $C_{17}H_{33}$, CO. OH, is found as a glyceride in almost all fats, solid and fluid, especially the latter. When pure, it crystallizes in colorless needles, which melt at 14° C. (57.2° F.); specific gravity, 0.898 at 14° C. (57.2° F.). When perfectly pure, it is soon oxidized in the air. With ioduretted hydrogen and phosphorus, when heated to 200° to 210° C. (392° to 410° F.) it passes into stearic acid.

Triolein, $C_3H_5(C_{18}H_{33}O_2)_3$, is a colorless neutral fluid, which is very little soluble in spirit of wine, but very easily soluble in ether. At body temperature it dissolves solid fats.

Another acid ("*Döglingsäure*") has been found in the blubber of *balæna rostrata,* as a glyceride.

T. Wesley Mills.

ACIDS. THERAPEUTICS.—The acids in general are substances, either solid, liquid, or gaseous, possessed of a sour taste, corrosive action, and the property of turning blue litmus paper red, and of combining with bases or their oxides to form salts. Two of the acids of the Pharmacopœia, however, carbolic and oleic, are, when pure, of a neutral reaction and will not redden litmus paper. The following-named substances are the ones which possess the characteristics of the acids in the most marked degree, and which are commonly understood when mention is made of this group. Though the Pharmacopœia contains many other drugs which are, chemically speaking, acids, nevertheless, as regards their therapeutic action, they belong rather to some other family, and will be more properly considered in connection with the other members of their respective groups. (See articles Antiseptics, Astringents, Disinfectants, Sedatives, etc.) The pharmacopœial "acids," commonly so called, and which will be here considered, are acetic, chromic, citric, hydrochloric (or muriatic), lactic, nitric, nitro-hydrochloric (or nitro-muriatic), phosphoric, sulphuric, and tartaric. To these may also be added arsenious and carbolic acids, which may, with propriety, be treated of here as regards their toxicology and external uses, and oxalic acid, which is of interest in this connection only as a poison.

Toxicology.—Before speaking of the therapeutic uses of the acids, a portion of the space allotted to this article may perhaps be profitably devoted to a very brief consideration of the symptoms and treatment of poisoning by these substances. The mineral—arsenious, carbolic, oxalic, and tartaric—acids are those from which poisoning, either by accident or design, most frequently occurs. When the mineral acids have been swallowed in concentrated form, the symptoms are those produced by a corrosive poison—intense burning pain in the mouth and throat, wherever the acid has come in contact with the mucous membrane, severe thirst, weak pulse, and dyspnœa. If hydrochloric or sulphuric acid have been taken the lips will show black stains, while the corrosive action of nitric acid colors the parts yellow. In cases of poisoning by these acids, alkalies should be at once administered in large draughts of milk or water. Any alkali that is nearest at hand may be used—chalk, tooth-powder, whitewash scraped from the ceiling, soap, or washing- or cooking-soda. The patient should then be made to swallow olive oil, melted butter, or lard. The attempt to use the stomach-pump in these cases should never be made, as serious injury may thereby be done to the softened tissues. (For the symptoms and treatment of arsenical poisoning, see under the head of Arsenic.) Poisoning by carbolic acid is evidenced by extreme depression, weakness of the heart, and dyspnœa. The breath is redolent of the drug, leaving little doubt as to the nature of the case. It is not very often that carbolic acid is swallowed in sufficiently concentrated form to produce severe local escharotic effects. When this happens the eschars are white in color. The treatment embraces the use of the stomach-pump or emetics, washing out the stomach, the administration of oily or mucilaginous drinks, and, later, stimulants to combat the depression. Poisoning by oxalic acid is not infrequent, owing to the resemblance of this substance to Epsom salts. Oxalic acid also exists in the leaves of the common rhubarb or pie-plant, and several cases of poisoning from eating these leaves have been recorded. This substance is an acro-narcotic poison, and when taken in toxic dose causes burning in the throat, intense gastric pain, vomiting, and collapse. Lime and magnesia are the proper antidotes, and should be given at once in large quantities, after which the stomach may be emptied by emetics or the pump. Potash or soda must not be given, as these alkalies form poisonous compounds with oxalic acid. After the immediate danger of death is averted by these means there remains a gastro-enteritis which is to be treated by the ordinary remedies. Instances of fatal poisoning by tartaric acid are extremely rare. The symptoms are those of an irritant, and consist in burning of the throat and stomach, with the signs of gastric inflammation. Any

alkali that is nearest at hand should be given, and the resulting gastritis is to be treated on general principles.

The therapeutic uses of the acids are varied and important, but their consideration here must necessarily be brief. For a detailed account of the individual properties of the acids the reader is referred to the special articles under their respective titles.

External Uses.—The stronger acids are markedly escharotic in their action, this property depending upon their strong affinity for the water and the bases in the tissues, and upon their power of coagulating and dissolving albumen. They are employed for the purpose of destroying new growths, removing sloughs, stimulating indolent and unhealthy granulating surfaces, cauterizing poisoned wounds, and, in diluted form, as astringents and hæmostatics. The caustic action of the acids is difficult of exact limitation, and hence they should not as a rule be used where only a superficial destruction of tissue is desired. They may be applied by means of a glass rod or a clean splinter of wood, and the surrounding integument should be protected by previously smearing it with oil or some other fatty substance. After the cauterizing action has proceeded far enough it may be in a measure limited, and the resulting pain relieved, by washing the part with an alkaline solution or soap-suds. The acids are used for the destruction of condylomata, small hæmorrhoidal tumors, nævi, chancres, and chancroids, to provoke healthy action in sloughing and phagedænic ulcers, and in uterine applications. Nitric acid, on account of its comparatively superficial action is the one usually selected for these purposes, though in many cases chromic acid is to be preferred. The latter penetrates deeply, and its application is not so painful as that of the former. Sulphuric acid is seldom employed as an escharotic, as it penetrates deeply and is with difficulty limited in its action; sometimes, however, it is selected because of these very qualities. It has been highly recommended, when diluted with two or three parts of water, as an application to carious or necrosed bone. Glacial acetic acid is one of the best applications for the removal of warts or corns. Carbolic acid (undiluted) is an excellent mild escharotic; it is employed for the removal of small condylomata, in the treatment of herpes, and as a uterine application. Somewhat diluted it finds employment in various ways as a local anæsthetic. Sponging the body with water acidulated with sulphuric or acetic acid is of service in excessive sweating, and it is also grateful as a refrigerant measure in feverish conditions. Dilute acetic acid or vinegar may be used to control epistaxis and other slight capillary hæmorrhages. Nitro-hydrochloric acid is employed externally in baths or on compresses applied over the liver in the jaundice due to cirrhosis or other chronic hepatic disorders. Hydrochloric acid was at one time, on the authority of Bretonneau, largely employed locally with a view to dissolving away the false membrane in diphtheria, but it has now, and justly, fallen into disuse. Lactic acid has also been recommended for the same purpose, but it is seldom so employed at the present day.

Internal Uses.—The acids are to be ranked among the antipyretics, since their power of reducing the body temperature in febrile conditions, though not very great, is yet not to be gainsaid; in healthy individuals, however, their effect upon the temperature is *nil.* Dilute hydrochloric is the best to use for this purpose, though, when an astringent effect is also desired, aromatic sulphuric acid may be substituted. The vegetable acids are frequently employed in the preparation of cooling drinks for fever patients. Citric acid or lemon-juice is the more palatable, but when for any reason this cannot be obtained, a very refreshing drink may be made by adding a little vinegar to sweetened water. Tartaric acid may also be used for the same purpose, but is inferior to citric. Perhaps the most frequent use of the mineral acids is in the treatment of dyspepsia, either to correct excessive acidity of the stomach or to supplement a defective secretion. Hydrochloric acid is the one usually selected, and is to be given before meals when the fault lies in too great acidity of the gastric secretions. When the opposite condition prevails, the acid is to be given after meals, and for this purpose lactic acid is preferred by many to hydrochloric; indeed, it is probable that when the latter is exhibited it is converted into lactic acid in the stomach. The acids just mentioned are also frequently employed when there is an excess of uric acid in the urine. In alkaline conditions of the urine the mineral acids, as well as citric or tartaric acid, are often of service. In hepatic disorders nitro-hydrochloric acid should be selected, and its internal administration, as mentioned above, may be supplemented by external applications. Carbonic acid water is of value in slight nausea and in the acute indigestion following excesses in eating or drinking. The mineral acids possess some value in the treatment of scurvy, but are far inferior to citric acid, especially as it exists in lemon-juice. The acids are also largely employed to control hæmorrhages of the uterus, lungs, or intestinal tract, especially of the first and last-named; in hæmoptysis they are of less efficacy. Sulphuric and phosphoric acids are the ones given for this object, but sulphuric is to be preferred. Aromatic sulphuric acid is used to restrain excessive sweating. Atropine and other drugs find more favor in the treatment of the night-sweats of phthisis; but in certain conditions, especially in corpulent individuals, in which profuse perspirations occur at night or follow upon very slight exertion, aromatic sulphuric acid given in ten or fifteen drop doses before retiring is very efficient. Care should be observed, however, not to continue its exhibition for too long a time, owing to the danger of disturbing the digestive functions. Sulphuric acid is useful as a temporary measure for the relief of lead colic, but it does not eliminate the poison from the tissues, and should never be relied upon to the exclusion of other more efficient remedies in the treatment of this condition. Workmen in lead factories make use of sulphuric acid lemonade as a prophylactic against poisoning, and the same drink is vaunted as a preventive of cholera. Sulphuric acid when added to Epsom salts markedly increases their purgative action. The acids, finally, are very often given, with or without iron, as a tonic. For this purpose either nitric, hydrochloric, or phosphoric acid is to be selected. For a certain class of nervous anæmic women who present an indescribable train of symptoms, various indefinite pains, nervous startings, palpitation of the heart, headache, etc., no tonic answers better than the following: Sulphate of iron, 12 grammes (ʒ iij.); nitric acid, 12 grammes (ʒ iij.); water, 90 grammes (℥ iij.); fifteen drops to be taken in water three times a day after meals. It should never be forgotten that the action of acids is very injurious to the teeth, and they should therefore always be taken through a glass tube. The mouth should immediately afterward be rinsed out with a solution of bicarbonate of soda or other weak alkaline solution, as a further precaution.

Thomas L. Stedman.

ACNE. Acne is an inflammatory, usually chronic, disease of the sebaceous glands, characterized by the formation of papules, tubercles, or pustules, or a combination of these lesions, occurring for the most part about the face. It may occur alone or in connection with other affections of the sebaceous glands, as comedo and seborrhœa. The lesions are of various sizes, from a pin's head to a large split-pea, and are commonly seen in both the papular and pustular, or the tubercular and pustular forms combined. There is not often any sensation of burning or itching, but occasionally a feeling of soreness when the lesions are touched. Their color may vary from bright red to dusky or violaceous, with usually a pustular centre. The number of lesions varies greatly in different cases. There may be only one or two present, or they may be very numerous. The inflammation may be superficial or it may be deep, even occasionally leading to the formation of abscesses. The individual lesions may come and go within a few days, or they may be of slow evolution, but the disease itself is apt, in all cases, to run a chronic course, the process

frequently lasting for years. If there has been much suppuration, more or less unsightly scars may remain.

The chief seat of acne is upon the face, neck, shoulders, and chest, although it may occur upon any part of the body, except the palms and soles. The severity of the disease varies very greatly. In some instances it may be represented by one or two lesions only, while in others the face, neck, shoulders, chest, and even the whole trunk may be covered with unsightly papules, pustules, suppurating tubercles, and abscesses.

Acne is one of the commonest diseases of the skin. In this country the statistics of the American Dermatological Association show its occurrence, in the practice of specialists, to be in the proportion of seven per cent. in all diseases of the skin, and its comparative frequency among the people is probably much greater. Acne occurs in the young of both sexes, appearing about the age of puberty. It does not occur in children, and only rarely makes its appearance for the first time in mature years.

Acne may occur in several different forms, described as "acne punctata," "acne papulosa," "acne pustulosa," but all these are stages of the same process, and all may usually be found represented in the same individual simultaneously. As one kind of lesion rather than another usually predominates, it will be convenient to consider the affection more closely under several heads.

Papular acne is the earliest stage of the disease, and is chiefly characterized by the occurrence of papular lesions, of pin-head to small-pea size, flat, or more or less pointed, lightish in color, situated about the sebaceous follicles, and often showing a minute black point, which indicates the mouth of the sebaceous duct. This variety of acne is often accompanied by comedo. (See Comedo.) There are usually a few pustular lesions scattered among the papules. The latter are not acutely inflammatory, and papular acne is the least developed form of the disease.

Pustular acne is the typical form of the disease, though even when fully developed pustules form the chief feature of the eruption many lesions of a papular and intermediate character are found. The pustules are pin-head to large-pea size, rounded or acuminate, seated on a more or less infiltrated base of superficial or deep inflammatory product. Suppuration may be slight or abundant. Occasionally several lesions run together, or the suppurative process extends more widely and deeply, and abscesses form. Such lesions are apt to occur about the lower part of the face, neck, and chest, but chiefly on the shoulders and back, forming the most serious and annoying phase of the disease. The smaller pustular lesions may heal up without a scar, while the larger ones leave a pitted cicatrix like that of small-pox. When abscesses form, very deforming cicatrices, with pockets or bridles of tissue, and with large comedones about or in them, may result. The disfigurement thus produced is increased by the occasional supervention of keloid in the cicatrix, but the lumpy scars thus produced usually assume the ordinary cicatricial condition after some months, the keloidal condition spontaneously disappearing.

"Artificial acne" is sometimes observed as the result of the external employment of tar, chrysarobin, and other agents. The acneform eruptions produced by the ingestion of various medicinal substances, will be found described under the head of "Dermatitis medicamentosa."

The causes giving rise to acne are numerous and varied in their nature. In its commoner forms it appears to be dependent, to some extent, upon the character of the skin. Persons with thick oily skins are most apt to suffer from the diffuse form of acne with numerous papular and pustular lesions mingled with comedones, while the sparse eruption of flat and papular lesions is often found in pale, anæmic individuals, with dry, rather harsh skins. The most frequent cause of acne is puberty. The affection shows itself for the first time, in the vast majority of cases, at this period, and is apt to continue, unless remedial measures are adopted, until the system has assumed the equilibrium of adult life, or in women until a later period.

Other causes which may, either alone or combined, give rise to the occurrence of acne, are scrofula and cachexia or general debility, anæmia, and chlorosis.

Habitual derangement of the alimentary canal is of great importance in the causation of acne, and dyspepsia, with, or more rarely without, constipation will be found present in the majority of cases. Very often a fresh attack of acne, with a new crop of lesions, follows closely upon each attack of dyspepsia or constipation.

Disorders of menstruation are often the direct cause of acne, and in many women suffering from this skin affection, a fresh outbreak may be expected before, during, or just after each menstrual period. At other times the cause of the disease remains obscure, the patient enjoying otherwise good health.

The anatomical seat of the inflammation in acne is about the sebaceous glands and hair-follicles, with their common opening. In the milder forms of papular acne (acne punctata) we have a comedo about which the surrounding papillæ and corium show enlarged blood-vessels, serous effusion, and exudative cells in the widened network. When the process goes on to form pustular acne, there is purulent exudation in the gland-ducts. When larger tubercles and pustules are found, extensive inflammation of the glandular structure and surrounding tissues with purulent collections in the gland-duct, and hair-follicle, and loosening of the hair-sheath, with destruction of the epithelium, is observed. When the inflammation is more intense, the sebaceous gland may be entirely lost in the suppuration, while the hair-follicle may escape. In large acne abscesses, gland, hair-follicle, and all are swallowed up in suppuration.

The *diagnosis* of well-developed acne presents no difficulty. When only a few lesions are present, however, and especially when these are illy developed, it is by no means easy, at times, to decide whether we have to deal with this affection or with others of a widely different nature. The age of the patient, the seat of the lesions, their chronic character, and their inflammatory nature, must be taken into account. Tar acne may be recognized by the smell of that drug, and acne due to chrysophanic acid by the purplish discoloration of the skin where it has been applied. In both forms of acne the presence of the drug in the follicles causes a marked appearance of black points. Acne may be distinguished from the similar eruptions due to iodine and bromine (see Dermatitis medicamentosa) by the fact that the lesions in these drug eruptions are apt to be larger, and that they come out in considerable numbers simultaneously. In addition the lesions are of a brighter and more inflammatory nature in the drug eruptions, and when fully developed are apt to cluster together, coalesce, and form inflammatory areas covered with characteristic crusts. The lesions of true acne rarely occur in groups or coalesce, and never show the cheesy sebaceous secretion of the acneform dermatitis from the ingestion of drugs. Acne often closely resembles the papular and pustular syphilodermata, and the two affections are not infrequently mistaken for one another. The history of the case, the presence or absence of characteristic lesions on other parts of the body not ordinarily attacked by acne, the uniform or scattered distribution of the lesions, those of syphilis tending to group, are all elements of the diagnosis which must be taken into consideration. When the syphilitic lesions occur on the forehead, or only to the extent of one or two about the nose, without any history, it is sometimes difficult to make the diagnosis, and great caution must be exercised in coming to a decision at the first examination. Acne in a severe and pustular form looks not unlike small-pox, but the absence of fever or other concomitant symptoms, and the chronicity of the acne eruptions, should prevent this mistake from being perpetrated even by one quite unacquainted with skin diseases.

The *treatment* of acne should be both constitutional and local. In order to use the constitutional treatment with effect, we must first ascertain by careful cross-

examination of the patient exactly what is the weak point. If constipation exists, this must be remedied. If dyspepsia is present, a careful regimen, with remedies appropriate to the peculiar form of digestive disturbance operative in the case under consideration, must be employed. When uterine difficulties present themselves as probable causes of the acne, these must be attended to, and, in short, to deal successfully with acne, the physician must be a master of his art. Of course, only the outline of treatment can be given in an article like this, and the treatment must be varied to suit the case.

When anæmia seems to be the efficient cause, without concomitant digestive difficulty, iron and arsenic alone or combined are called for. The tincture of the chloride in five to ten minim doses, always prescribed in water, so that the patient is not left to measure out the drops, is one of the best forms of iron to use alone. The arsenic is preferably given in the form of Fowler's solution in water or in wine of iron; the dose at first should not be more than two to four minims, which may be gradually increased to eight minims if the case require it: beyond this it is rarely advisable to go. Constipation is a very common accompaniment of acne, and should always be removed. Saline or vegetable laxatives, with an occasional dose of blue pill, is useful in some cases. The majority of patients will get along best under the admirable mixture devised by Startin, and known as "Mistura ferri acida." It is composed as follows: ℞. Magnesii sulphat., ℥ j. (31 grm.); ferri sulphatis, gr. iv. (.26 grm.); sodii chloridi, ʒ ss. (1.95 grm.); acid. sulphuric. dil., f ʒ ij. (7.75 grm.); infus. quassiæ, ad f ℥ iv. (120 grm.). M. Sig.: A tablespoonful in a tumbler of water before breakfast. Although a very disagreeable mixture to most persons on first taking, it usually agrees well with them, and becomes less revolting after use for a short time. In the dyspepsia with constipation of acne it is an incomparable remedy. Its use should be governed by the effect on the bowels. If it is too purgative the amount can be diminished, or if not sufficient laxative effect be produced the proportion of magnesium sulphate can be increased, or the dose repeated before supper, or it may even be given thrice daily. The natural mineral waters are sometimes useful in acne, especially the Hathorn water of Saratoga and the Hunyadi Janos as sold in the bottled form.

Where there is much irritability and hyperæmia accompanying the acne, good results are often gained by the prolonged administration of alkalies. Taylor recommends the following formula: ℞. Potassii acetatis, ℥ j. (31.10 grm.); sodii et potassii tart., ℥ ij. (62.20 grm.); syr. zingiberis, f ℥ ij. (60 grm.); aquæ, q. s. ad f ℥ viij. (240 grm.). M. Sig.: A tablespoonful in a wine-glass of water after meals.

When there is a scrofulous taint, and especially in those cases in which there is a tendency to the formation of abscesses, cod-liver oil is indicated. Occasionally, when this disagrees, extract of malt may be substituted. The bitter tonics and mineral acids are likewise of value in many cases.

Hygiene is of the utmost value in the management of acne, and the beneficial effect of change of air, particularly to mountainous regions, is often more marked than that of drugs. The sea-shore, it may here be remarked, usually disagrees with acne patients. Exercise in the open air, cold bathing, moderate gymnastics, all are of use. Occasionally a sea voyage benefits a patient whom medicines have failed to relieve.

The local treatment of acne is of great importance, especially with regard to the choice of remedies. Applications innumerable are recommended in the books and in periodicals, but only a few are generally useful. Some cases of acne show acutely inflammatory symptoms, and must be treated by means of soothing applications, of which the bland ointments and lotions used in acute eczema are examples. (See the treatment of acute eczema.) But by far the greater number of acne cases demand stimulant treatment, often of a vigorous sort. When the skin is coarse and sluggish, with numerous comedones and a general greasy look, and without much acute inflammation, frictions with alkaline soaps, as sapo viridis or the solution of the latter in one-half its weight of alcohol, known as "spiritus saponis alkalinus," are of use. These should be briskly rubbed in and then washed off the skin again, and followed by applications of cold water or of powdered starch. Occasionally a solution of potassa, fifteen grains to the ounce of water, may be applied with advantage, followed by a stimulant ointment, as the following: ℞. Ung. hydrarg. præcip. alb., ʒ j. (3.90 grm.); ung. aquæ rosæ, ʒ iij. (11.65 grm.). M. Sulphur and its preparations are among the most valuable remedies in our possession for the treatment of acne in most of its forms. The following is a generally useful formula: ℞. Sulphuris precipitat., ʒ j. (3.90 grm.); ung. aquæ rosæ, vaselini, āā ʒ iv. (15.50 grm.). M. Camphor may sometimes be added in the proportion of a scruple (1.30 grm.) to the above formula. Sometimes lotions are more suitable, especially where there is a tendency to rosacea (see Acne Rosacea). The following is a convenient preparation: ℞. Sulphuris precipitat., ʒ j. (3.90 grm.); pulv. camphoræ, gr. v. (.32 grm.); pulv. tragacanthæ, gr. x. (.65 grm.); aquæ calcis, aquæ rosæ, āā f ℥ j. (30 grm.). M.

When the lesions are sluggish, and especially in indurated acne of the back, Vlemingckxs's solution is a valuable local application. ℞. Calcis vivæ, ℥ ss. (15.50 grm.); sulphuris sublimat., ℥ j. (31.10 grm.); aquæ, f ℥ x. (311 grm.). Boil down to six ounces and filter. This is a very stimulating application, almost caustic in fact, and should always be diluted with several parts of water before using, at least until the effect upon the skin has been ascertained.

Indurated and pustular acne may sometimes be benefited by the application to each lesion of a drop of solution of the acid nitrate of mercury on the end of a sharpened match, followed by bathing with hot water. The lesions may also be punctured with a sharp instrument when there is a tendency to the formation of abscesses. (See Fig. 53.) The severer plans of treatment, as rubbing with sand, scraping with the sharp spoon, are not particularly beneficial, and are usually objected to by patients. In some cases the use of sulphur soaps, applied in lather and allowed to dry on, is of advantage.

Whatever plan of treatment be adopted, it is essential that it should be thoroughly carried out, and the patient should be frequently examined to ascertain if the directions have been complied with. In any case the prognosis should be guarded. The more extensively developed cases are very often more amenable to treatment than those where half a dozen lesions alone represent the disease, and where the patient enjoys apparently good health. The question is, in the long run, one of time only, as a spontaneous cure sooner or later invariably occurs. If neglected, however, unsightly and disfiguring scars, sometimes keloidal, supervene in severe cases, and unremitting efforts should, therefore, be used to obtain, if possible, a speedy cure.

Arthur Van Harlingen.

ACNE ROSACEA. Acne Rosacea is a chronic, hyperæmic, or inflammatory disease of the face, more particularly the nose, characterized by redness, dilatation and enlargement of the blood-vessels, hypertrophy, and more or less acne. Hyperæmia is the first symptom, and this shows itself in a diffuse flush on the nose and neighboring parts, and in some cases over the cheeks, chin, and even the ears. This may at first occur only intermittently, but after a longer or shorter period the redness becomes settled, more marked, and permanent. A condition at first only brought on by exposure to cold or a close atmosphere, or following the use of alcoholic stimulants or a full meal, finally becomes habitual. Small tortuous blood-vessels can be seen ramifying over the tip of the nose and the prominence of the cheek-bones, the nose is cold to the touch and often shows slight seborrhœa. This condition may remain stationary for months, or even years, and may then disappear, or it may go on to the gradual formation of pin-head to split-pea-sized hard papules, either isolated or grouped into indurated masses. This second

form shows best the combination of conditions which has given the affection its name, acne rosacea. A third and much rarer variety affects the nose alone, and consists in an inflammatory connective-tissue hypertrophy, with enlargement of the sebaceous follicles and hypertrophy of the papillary layer of the corium. The organ becomes grotesquely enlarged and misshapen, the surface rugous and covered with irregular, sometimes overlapping growths, showing enlarged and tortuous blood-vessels, thickly strewn with acne pustules and with the blackened points of comedones and of a deep vinous red color. At other times the surface remains smooth and shining, while a uniform thickening of the skin causes great increase in the size of the nose.

The *causes* of acne rosacea are various. The first two varieties may occur in men as well as in women, but the third is found in men alone. In women the disease is apt to be connected with disturbance of the generative apparatus. Dyspepsia, anæmia, and chlorosis are also among the causes. Habitual indulgence in alcoholic and malt liquors is among the commonest causes, although the disease is in no sense an indication of alcoholic indulgence, as it is very common among dyspeptic water-drinkers. Persons whose business or profession leads to much exposure to inclement weather, as hack-drivers, sailors, etc., are apt to become the subjects of acne rosacea. The immediate cause of the lesion is paresis of the most minute capillaries of the skin at their extremities, leading to chronic enlargement and sluggish circulation.

Fig. 52.—Acne Rosacea. (After Duhring.)

The *pathology* of acne rosacea is in part explained by what has been said regarding its etiology. In the first variety or stage there is simply a blood stasis in the skin. This condition may last for years without change. Sooner or later, however, permanent dilatation and hypertrophy of the capillaries takes place, together with an involvement of the sebaceous glands in the form of acne. Still later more or less hypertrophy of all the tissues of the affected part takes place, and a connective-tissue new-growth is the result, with the marked distortion above described. Piffard has described a case, microscopically examined by him, where the horny layer was scanty, but the rete mucosum thick with well-formed cells. The papillæ were enlarged in length and breadth, and contained round and fusiform cells. Some of the sebaceous glands were unaltered, others were undergoing degenerative changes. The corium was greatly thickened, and presented the appearance of a formed tissue.

The only diseases with which acne rosacea is liable to be confounded are syphilis, lupus vulgaris, lupus erythematosus, and acne. From the tubercular syphiloderm acne rosacea is to be distinguished by its chronicity. The syphiloderm is indeed chronic, but it lasts months where acne rosacea lasts years. In syphilis the lesions do not especially involve the glands, in acne rosacea the glands form the centre of the pustular lesions. Crusts are apt to be present in syphilis, and some of these on removal show ulcers beneath. Ulcers never form in acne rosacea. The color of the syphilitic eruption is apt to be a dull, coppery red; in acne rosacea the color is either a bright red or violaceous, according to the stage of the disease and its form. The characteristic enlargement of the blood-vessels seen in acne is wanting in syphilis. Syphilis occurs on one side of the nose more than on the other in many cases, whereas acne is symmetrical. In doubtful cases the history may be of some aid, but is not always to be depended upon.

The characteristic roundish, reddish, or yellowish papules or tubercles of lupus vulgaris, pin-head or larger in size, and usually involving only a portion of the nose, as the tip or one ala, usually serve to distinguish this affection and to prevent its being mistaken for acne rosacea. Moreover, ulceration, followed by crusts and disfiguring cicatrices, is present in lupus vulgaris, but is absent in acne rosacea.

Sometimes lupus erythematosus, when it occurs upon the end of the nose, may be mistaken for acne rosacea, but the presence of sebaceous crusts, with the wide-open mouths of the oil-follicles, are characteristic of this form of lupus, and are quite absent in acne rosacea.

From acne the affection under consideration may be distinguished by the presence of enlarged blood-vessels and by the hyperæmia. As the line dividing acne and acne rosacea is in some cases an arbitrary one, and as the former may merge into the latter, of course many cases are practically undistinguishable.

The *treatment* of acne rosacea varies with the stage of the disease and with the cause in the given case. Constitutional and local remedies are both to be employed. The cause of the disease is in each case to be diligently sought out and, when possible, removed. Especially is this the case when disorders of the generative apparatus in women are involved. The stomach and bowels are to be kept in good order. Iron, arsenic, and bitter tonics are to be used as occasion requires. Change of air to the mountains, or to the sea-shore, may in some cases be required.

Locally, the acne lesions when present are to be gotten rid of by the remedies above described under acne. The sulphur preparations are the best, both for this purpose and for the removal of the rosaceous condition, and the sulphur and tragacanth wash, described above, may be applied frequently with the greatest benefit. G. H. Fox recommends the following: ℞. Pulv. chrysarobin, ʒ ss. (1.95 grm.); collodii, f ℥ j. (32 grm.). This is to be painted over the affected part daily, the effect being watched with the view of avoiding possible untoward results from over-action of the chrysarobin. In the later stage, when well-defined blood-vessels can be seen coursing under the skin in numbers, the treatment must be different.

Fig. 53.—Acne-punctor.

The dilated capillaries may be incised with a fine, sharp knife, in the hope that adhesive inflammation may result, with the effect of closing the calibre of the vessels. Cold water compresses or pledgets of dry lint may be applied to control any bleeding, and a small number of vessels may thus be operated upon thoroughly until the ground has been entirely gone over. A lance-headed punctor (Fig. 53) may be used for the same purpose, small punctures being made in the line of the dilated vessels at short intervals. Hardaway recommends electrolysis, using a No. 13 cambric needle inserted into any convenient handle, and connected with the negative pole of a galvanic battery; a sponge electrode is then connected with the positive pole. The needle is inserted sufficiently deep to enter the dilated vessel; as soon as this has been accomplished the patient completes the circuit by taking the sponge electrode into his hand. When the electrolytic action has been properly developed, the patient releases the sponge electrode, after which the operator withdraws the needle. Six or eight elements will generally suffice. If the vessel to be operated upon is a long one, several punctures must be made at suitable intervals of space. The needle may be inserted perpendicularly or in a line with the course of the vessel. One discouraging fact must be taken into

consideration in the endeavor to heal acne rosacea by means of destruction of the calibre of the enlarged blood-vessels, that is, that a collateral circulation is apt to be established which will bring the same condition of the skin back again, and which must be expected and met by a renewed operation. In these rare and severe cases of acne rosacea, when knobby and gross hypertrophic deformity of the nose exists (Fig. 52), decortication with the knife is the only effectual remedy, although in less advanced cases scraping with the sharp spoon may improve the condition of the skin to a considerable degree.

The *prognosis* in the early stages of acne rosacea is favorable, and there are few affections of the face in which more striking and rapid results can be attained, up to a certain point, than in these cases of acne rosacea where there is a red, flushed condition of the face, with numerous acne papules and pustules, and with little or no distinct capillary dilatation. When, however, the disease has become thoroughly established, only thorough and long-continued treatment will avail. When the capillary enlargement is already marked, treatment beyond a certain point is only palliative; it may prevent further progress—a result of no small value, and patients should be encouraged to persevere.

Arthur Van Harlingen.

ACONITE [*Aconitum*, U. S. (the root); *Aconitum napellus* L. (*Delphinum aconitum* Baillon); order *Ranunculaceæ*, Monkshood] is a tall, handsome herb, with large, irregular, purplish blue flowers, compound leaves, and a fleshy, conical, biennial—but by stolons, perennial—root. It is a variable and widely distributed species, growing abundantly in the mountainous districts of Central Europe, Asia, and the western part of America; extending up the mountain sides to a very high elevation, as well as deep into the valleys. It is cultivated for medicinal use in parts of continental Europe and England, and as an ornamental flower in the United States, where it occasionally escapes from gardens, and takes an uncertain possession of waste places.

The aconites were known to the ancients, both in Europe and Asia, as poisons, and are said to be still used by some of the hill tribes of India to envenom their arrows. They were employed as medicines in Germany in the twelfth, and on the island of Great Britain in the thirteenth centuries; but afterward fell into disuse until 1762, when Stoerck, of Vienna, again introduced them to the medical profession, since which time they have been constantly but not extensively used.

FIG. 54.—Delphinum Aconitum (Baillon).

The simple, stiff, upright stem of aconite rises from fifty to one hundred centimetres (twenty to forty inches) from the ground, bearing numerous alternate leaves, and a long, close, terminal, spike-like raceme.

The leaves (*folia aconiti*, Br. Ph.; *feuilles d'aconit napel*, Codex Med.) are from five to twenty centimetres in diameter (two to eight inches), are rather stiff and thick, smooth, shining, and dark green above, and paler below. The blade is palmately three-parted; the lateral segments are again divided nearly to the base. The narrowly wedge-shaped divisions are further three- or two-lobed, and these lobes are again incised, or cleft, with linear or pointed tips. The leaves become less compound toward the upper part of the stem, and are finally reduced to three- or several-cleft bracts. They have no marked odor, but upon being chewed, produce, like the root, a persistent stinging sensation in the mouth. They contain a small and uncertain amount of *aconitine*, and considerable *aconitic acid;* the latter of no therapeutic importance. The flowers are of striking appearance; the corolla is nearly wanting, and its place is taken by a large, colored calyx, of which the upper sepal is developed into a deep cup-shaped helmet, that sits upon the rest of the flower like a bonnet. The pistils are three, containing numerous small ovules.

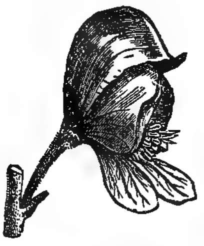

FIG. 55.—Entire Flower of Aconitum Napellus.

The mature root gives the specific name to the plant (*napellus*, a little turnip). It is a simple, conical, tapering tuber, ending in a long, slender, cylindrical tap-root, and bearing numerous rootlets upon its sides. (See Fig. 57.) From its scaly crown arises the flowering stem, and at the base of this stem a short stolon extends horizontally under the ground, and bears, on its extremity, a young tuber, more or less developed according to the season, and destined to produce the plant of the succeeding year. There may also remain upon the other side of the crown a similar but dead connection between the present root and the remains of that of the preceding year.

Fresh *aconite root* is brown externally, white within, and has a biting, benumbing "taste," which has caused it to be occasionally stupidly mistaken for horseradish.

The *dried root*, which constitutes the usual drug (*aconitum*, U. S. Ph.; *aconiti radix*, Br. Ph.; *tubera aconiti*, Ph. G.; *racine d'aconit napel*, Codex Med., etc.), is from one to two centimetres in diameter at the base, and from five to seven inches in length (two-fifths to four-fifths inch by two to three inches); much shrivelled and wrinkled longitudinally, especially below; often curved and twisted, or broken. The external color is dark brown; internally it is grayish, showing, in a transverse section, a distinct, five- to eight-pointed stellate cambium ring, in each angle of which is a well-developed fibro-vascular bundle. Frequently the roots are attached in pairs; when not, the scar where they were broken apart can be seen. The taste is similar to that of the fresh root, but the stinging sensation may be a little slower in coming.

FIG. 56.—Seed-vessel of Aconitum Napellus.

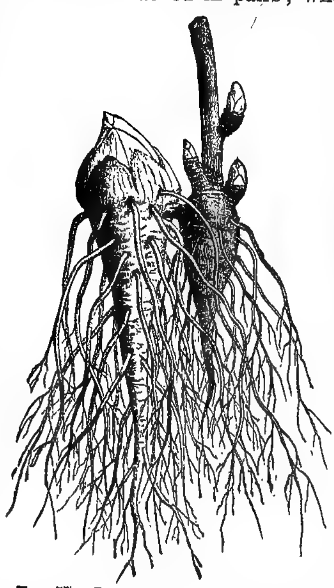

FIG. 57.—Root of Delphinum Aconitum (Baillon).

Aconite root, even when coming solely from *aconitum napellus*, is very variable in quality and often poor. The age of the root has much to do with this; when gathered just before blossoming it is large and juicy, and of the best quality; after this it rapidly deteriorates, and the autumn-flowering root is worthless. The young root, in the autumn or spring, however, is of good size and next in value to the first named. Light, hollow, rotten-stemmed pieces should be discarded. Grown in different countries, or under varying circumstances, it is subject to considerable variation in

quality. Commercial aconite is also frequently mixed with the tubers of several other similar but less active species. On the whole, it is one of the most unreliable medicines in the market.

Aconite owes its medical value and poisonous qualities to the alkaloid *aconitine*, which it contains, associated with one or two others, and in combination, probably, with *aconitic acid.* It was discovered in 1833 by Geiger and Hesse in the leaves of *aconitum napellus*, and afterward, in the root, by Bley. It exists also in several other species in smaller quantity. Although easily separated as an amorphous powder of varying quality, it has proved to be an exceedingly difficult base to prepare in a state of chemical purity. Groves first obtained it in crystals. Duquesnel, and finally Wright and Luff, have distinguished themselves in more recent studies upon it. Crystallized aconite is now offered as an article of commerce by several chemists, especially by Duquesnel of Paris, whose product is considerably used in the United States. It is in regular rhombic tables, or short four-sided prisms, or often in small crystalline masses, anhydrous, nearly insoluble in water, but soluble in alcohol, ether, etc.; usually not quite white, often pale brownish yellow, of a bitter taste, which is followed by an intense prickling of the mouth and fauces (it must only be tasted with great care in a dilute solution). The nitrate is similar to the above, but more soluble.

According to the conclusions of Messrs. Wright and Luff (*Pharmaceutical Jour. and Trans.*, 1875 *et seq.*), aconite contains also another similar and equally poisonous crystalline alkaloid, but in very minute quantity, namely, *pseudaconitine*, the alkaloid of *aconitum ferox* (see below). Both these bases exist also in an uncrystallizable condition. Besides these, two inferior bases, *aconine* and *pseudaconine*, are always found in the course of the examination, but as they are easily produced as decomposition products of aconitine and pseudaconitine respectively, their separate existence in the plant, although probable, is not proved. The ordinary commercial, amorphous "aconitine" is an uncertain mixture of all the above. "English aconitine" is said, by German chemists, to be pseudaconitine. Resin, fats, starch, gum, sugar, etc., are ordinary vegetable products found in aconite, but of no medical interest.[1] Too much value must not be placed upon the various estimates of the yield of aconite root. Flückiger ("Pharmakonosie des Pflanzenreiches") gives it as 0.04 per cent., the older authorities as much higher.

Aconitine, as would be expected, considering its active qualities, has been repeatedly and assiduously studied in its physiological aspects, but, excepting as far as its most evident action goes, much remains yet to be made sure. This is, in part, undoubtedly ascribable to the uncertainty of the composition of many of the preparations heretofore used, but it is in part also due to the peculiar difficulties presented by the drug itself. Its physiological properties appear to be the following:

First.—To disturb and reduce sensation. A mild feeling of prickling or tingling of the extremities and tongue is often noticed after one or two moderate medicinal doses, and is a recognized warning that the limit of its therapeutic use has been reached. In large doses this symptom is one of the first to appear, and becomes very intense, accompanied by diminution of sensation, due to anæsthesia of the surface and, perhaps also, of the deeper parts.

Second.—To paralyze the motor nerves. This is not as prominent an effect of aconitine as the preceding; and, after moderate doses, may be even unnoticeable, excepting as a slight clumsiness of the limbs; but in large ones is evident enough. Both the sensory and motor effects appear to begin, and have their intensest manifestation, at the surface, and to proceed gradually upward along the nerve-trunks. Whether a portion of them are also due to direct action upon the sensory or motor centres, in the brain itself, is still a matter of doubt, but not unlikely.

Third.—The depressing action of aconite upon the heart is one of its most prominent and dangerous qualities, as well as the one for which it is most often given. Slowness and feebleness of the pulse, and consequent reduction of the arterial pressure, are constant results of its administration; but how these results are brought about, whether by direct action upon the heart itself, or upon its nerve-centres, or all together, is not known. Much of the weakness attending aconite poisoning—the cold sweats, blindness, syncope, fall of temperature, etc., which occur—is undoubtedly due to the enfeebled circulation.

Fourth.—The respiration is retarded and enfeebled, probably from both peripheral and centric paralysis. Convulsions are not common; the mind is usually clear.

MEDICINAL USES.—One rational application of the above effects of aconite is to reduce the frequency and force of the heart's action, when uncomfortably or dangerously excessive. Conditions indicating its use are often present in acute febrile affections, especially at the onset: pneumonia, pleurisy, bronchitis, scarlet fever, and other exanthemata, as well as the febrile excitement attending the passage of the catheter, menstrual disturbances, coryzas, etc., are examples. Marked and grateful relief often follows, very quickly, the use of aconite in these cases; and, if the condition is a transient one, it effects an apparent cure. In the later stages of dangerous fevers, or when the fever is of an adynamic type, it should never be used. It sometimes relieves the palpitation of exophthalmic goitre.

Another application, which may be logically deduced from its action upon the nerves, is its use in certain painful affections, especially certain neuralgias, in which it occasionally gives marked relief—often, unfortunately, not any. The greater the probability the pain is trivial or peripheral in origin, the greater the amount of benefit which may be expected. It sometimes diminishes the vomiting of pregnancy, and may be useful in other cases where diminution of nervous irritability is desired.

Empirically, it has been used in many chronic diseases and *opprobria medica* without establishing itself in the treatment of any. Locally applied to painful parts, as a liniment or an "oleate," it is often more beneficial than when taken internally.

Administration.—Aconite is not often given in substance, but its dose, as authorized by the Pharmacopœia Germanica, may be taken as a standard for computing those of its preparations. The *maximum* single dose, according to that authority, is one decigramme (0.1 grm. = gr. jss.), or not more than five times as much in a single day. The officinal preparations are all made by first exhausting the root with alcohol, slightly acidulated by the addition of tartaric acid, and then evaporating or otherwise reducing to the standard of strength. They are: 1. Abstract of aconite (*abstractum aconiti*), in which the alcoholic liquid is evaporated nearly to dryness, and then standardized by the addition of enough sugar of milk to make the product weigh one-half the amount of aconite used. Full dose, therefore, five centigrammes (0.05 grm. = gr. $\frac{3}{4}$). 2. Extract of aconite (*extractum aconiti*), made by evaporating to a pilular consistence, and preserved from drying completely by the addition of a little glycerine. This product varies in strength from $\frac{3}{1}$ to $\frac{5}{1}$, according to the season in which the root was gathered, and other conditions. Dose uncertain. 3. Fluid extract of aconite (*extractum aconiti fluidum*), strength $\frac{1}{1}$. Dose, the same as that of the root. A good, but inconveniently strong preparation. 4. Tincture of aconite (*tinctura aconiti*), strength $\frac{2}{5}$; the most generally used form. Full dose, two and a half decigrammes (0.25 gr. = ♏ iv. gtt. viij.).

Aconitine is not officinal. The old amorphous preparation should never be used. Pure crystallized aconitine, or its nitrate, appears to be more uniform, and may be given in doses of three or four ten-thousandths of a gramme (0.0003 to 0.0004 grm. = gr. $\frac{1}{200}$ to gr. $\frac{1}{150}$).

Oleate of aconitine, a two per cent. solution of the above, is useful for painting painful surfaces, but should be used very cautiously.

Liniment may be made by mixing the tincture or fluid extract with other liniments.

Fleming's tincture is an old preparation, which, on

account of its strength (⅗), should be known; but it is better not to call for it, as it has no advantages over the United States tincture or fluid extract.

The above-mentioned are full adult doses, and should not be repeated more than three or four times a day without close watching. In febrile cases it is much better to divide each dose into twenty, and give, say a quarter of a drop of the tincture, every fifteen minutes until some effect is produced, than to give the larger doses less often.

BOTANICAL RELATIONS.—The genus aconite contains eighteen species, natives of hills and mountains of the northern hemisphere, like our species, showy, handsome, large-flowered, perennial herbs.

Aconitum ferox, Wallitch; Indian aconite, or bish, resembles the *A. napellus,* but has a larger, fuller, and longer root. It contains chiefly pseudaconitine, with a little aconitine. Qualities, similar to *A. napellus;* said to be more active. Supposed to be the source of some of the "English aconitine."

Aconitum variegatum, L., has short, roundish, egg-shaped tubers; Europe.

Aconitum Stoerckeanum, Rchb., has its tubers in threes, or even more together. Both the above species occur occasionally in lots of commercial aconite.

Aconitum —— ———, Japanese aconite, yields *Japaconitine;* very poisonous; similar to aconitine.

Aconitum lycoctonum, L., has yellow flowers and branched, not tuberous, root; poisonous.

Aconitum heterophyllum, Atis, a yellow-flowered species, native of the Himalayas, yields a bitter, not poisonous alkaloid, *atisine;* used in India as a tonic and antiperiodic!

The natural order *Ranunculaceæ,* of which aconite is, medically, the most important member, contains between five and six hundred species, distributed over nearly all parts of the globe, but especially abundant in the northern temperate zone. It furnishes our gardens with scores of beautiful flowers—clematids, anemones, buttercups, the Christmas rose (hellebore), columbines, larkspurs, monkshoods, peonies, etc.—the medicinal plants being among the number. They are, as a rule, herbs (occasionally soft-wooded shrubs or vines) with large, handsome flowers, alternate, more or less divided leaves, and a clear juice. They have a bitter, often peppery, biting taste, which benumbs the tongue, and frequently leaves it anæsthetic for several hours. Their principal active constituents are anemonin, helleborin, delphinine, aconitine, and berberine; all but the last are intense poisons, having a strong family likeness.

Although it contains some perfectly innocent plants, the general character of the order is poisonous. The following enumeration of its most important genera will give an idea of its qualities:

Clematis, poisonous vines, having a benumbing, biting taste, irritant and vesicant, have been used both internally and externally; now obsolete; contain a pungent stearoptine allied to anemonin.

Adonis, a European wild flower, contains "adonin," an active heart-poison resembling digitalin.

Thalictrum: several species said to resemble aconite in poisonous properties; active principle, thalictrin.

Anemones (see Pulsatilla) contain a poisonous substance, which finally separates into anemonin and anemonic acid.

Ranunculus: numerous species of ranunculus appear to have properties similar to pulsatilla, and to contain also anemonin; not now used.

Hydrastis (see Seal, Golden): not poisonous; contains hydrastine, berberine, etc.

Helleborus (see Hellebore, Black), an active heart-poison, resembling digitalis; also drastic, like many other ranunculaceæ; contains helleborein and helleborin.

Coptis: not poisonous; contains berberine and "coptine." (See Goldthread.)

Delphinium (see Stavesacre): very poisonous, and somewhat like aconite; contains delphinine, etc.

Aconitum, various aconitines.

Cimicifuga (see Snake-root, Black): active principle and qualities not definitely known.

Xanthorrhiza, not poisonous, contains berberine; obsolete.

Pæonia: not active; properties obscure; obsolete.

ALLIED DRUGS.—Besides those given above in the section upon allied plants, the following may be mentioned: *Veratrum viride,* as a cardiac depressant, acts very much like aconite (and is often employed for similar conditions), as also do the now comparatively little used tartar emetic and tobacco. As a peripheral anæsthetic, the local anæsthesia produced by cold gives much the same subjective results. It is too early yet to say whether cocaine will take its place. Carbolic acid, locally applied, benumbs the nerve extremities. There is no other drug known which, taken internally, has exactly the effect of aconite. *W. P. Bolles.*

[1] For a detailed *résumé* of the chemical history of aconite, see Husemann's Pflanzenstoffe, 2d ed., i., 624.

ACONITE. TOXICOLOGY.—The first symptoms of aconite poisoning are manifested in from five to twenty minutes after a toxic dose has been taken, and are those of an acro-narcotic poison. There is burning in the throat and stomach, and soon a tingling sensation is felt in the extremities, and extends over the whole body; at the same time there is numbness, proceeding even to anæsthesia of the integument. There is a very brief period of cardiac stimulation, but the pulsations are speedily reduced in frequency and force, then becoming irregular and fluttering, and finally cease. The respirations are infrequent and shallow, gasping, and then are arrested altogether. The skin is livid, cold, and bathed in a clammy perspiration. The eyes are staring, and the whole countenance is expressive of great anxiety. The pupils are, as a rule, dilated, though they may be contracted or normal, and vision is often disturbed. There is extreme muscular weakness. Nausea and vomiting are not infrequently noted, and retention of urine is a common symptom. The temperature, both internal and external, is lowered, sometimes as much as 2° F. (1.1° C.). Convulsions sometimes occur, but consciousness is usually preserved to the end, except during the convulsive seizures. Death often occurs in syncope, after some slight exertion. The characteristic sign of aconite poisoning is the peculiar numbness and tingling of the integument and buccal mucous membrane. In cases of recovery, the effects of the drug have usually almost entirely passed off at the expiration of from three to six hours, and by the following day the patient is in his ordinary health, except that he feels weak and languid.

Poisoning by aconite is not a very rare accident, since at the present day the drug is so extensively used in the febrile conditions of childhood that it has come to be regarded almost as a domestic remedy, and a bottle of the tincture may be found in nearly every house. Many cases of poisoning have occurred also from eating the root by mistake for horseradish, which it greatly resembles. Children sometimes chew the leaves of the plant, and are poisoned in this way. Great care should be observed in the employment of aconitine, since toxic symptoms have followed its external application to an extensive surface. It should never be given internally, as very alarming symptoms have followed the ingestion of $\frac{1}{50}$ grain (0.0013 grm.) Recovery has been recorded after the swallowing of an ounce (30 grms.) of Fleming's tincture.

Treatment.—After the stomach has been emptied by emetics or the pump, prompt measures must be taken to sustain the action of the heart. The patient should be kept in a recumbent position with the head low, and should on no account be permitted to sit up or stand. Stimulants, ammonia and alcohol, should be given by the mouth and hypodermically, and external warmth applied to the body. Strychnine, digitalis, or atropine, are to be given for their cardiac effects. There is no chemical antidote to aconite, though astringents and animal charcoal are said to be useful.

Thomas L. Stedman.

ACQUI, Lat. 44° 40′ N., altitude, 129 metres (423 feet), a Piedmontese watering-place of considerable repute, situated in the beautiful valley of the Bormida, within easy reach of Alessandria by a branch railroad, or of Nizza by stage. The bathing establishment is situated on an elevated plateau, which is planted with mulberry trees, and is distant about a mile from the town, in a southerly direction. The medicinal hot springs at this point do not possess either the thermal force or chemical value of the "Bollente," a spring which is located within the precincts of Acqui itself, but which has fallen into complete disuse. No satisfactory analysis has been made of the waters of these springs, but they are said by Baedeker to be not unlike those of Aachen. The chief chemical constituents are sulphur, in inconstant but not inconsiderable proportions; sodium chloride, and earthy sulphates. There are also traces of iodine and carbon dioxide. The cold springs of Puzzolente or Ravanesco, which are situated at some distance from the others, have essentially the same chemical composition. The temperature of the waters varies from 17.9° to 43° C. (64.5° to 109.4° F.). Although mention is made of certain sulphur springs whose waters are used as a beverage, and although the "Grande Vasca" and "Hemicycle" are employed for bathing purposes (both the douche and the ordinary bath), yet the customary mode of employing these medicinal waters is in the form of mud baths. The sediment which collects in the basins of these springs, and which consists partly of soil and partly of sulphur, various salts of slight solubility, and a little organic material, is removed in the month of April to large reservoirs, and thoroughly mixed with the thermal water. The resulting mass is a greyish, soft, unctuous mud. The temperatures of the mud in the different reservoirs are, respectively, 31° C. (88° F.), 43.5° C. (110° F.), and 51° C. (124° F.). The bather does not enter the reservoir, but is laid upon a mattress, and the affected part of the body is then plastered with a layer of the warm mud to a depth of five or six centimetres (about two inches), and enveloped in thick cloths. According to the thickness, extent, and temperature of this mud plaster, the immediate effects are an acceleration of the pulse, increased heat of skin, profuse perspiration, redness of the skin, and even, at times, an eruption of one kind or another. These mud-baths are particularly efficacious in the various forms of rheumatism. Sciatica of the worst type is often not only benefited, but in many very rebellious cases a complete cure is obtained After the mud has been removed, the patient is put into an ordinary warm bath, of moderate temperature, and allowed to remain there for from fifteen to forty-five minutes.

The bathing establishments of Acqui are the most extensive to be found in Italy (Eulenburg).

Henry Fleischner.

ACROMION PROCESS, Injuries and Diseases of. Very little appears to have been written on diseases and injuries of the acromion process, except in relation to simple fractures of the part. A few cases only of caries and necrosis have been reported; not more than one case being reported by the same writer. In no instance is there anything more than a brief report of the case; nothing being said in general as to the symptoms and treatment of these diseases. Nothing appears to have been written concerning new-growths of this process.

Injuries.

The principal injury, in fact the only one of importance, to which the acromion process is subject, is fracture. This may be simple or compound.

Simple Fracture.—Fracture of the acromion process is a very uncommon accident. It is, however, the most frequent of fractures of the scapula. Out of 1,901 cases of fracture (Middlesex Hospital) 18 only were of the scapula, and 8 of these were of the acromion process. Out of 1,578 cases of fracture (Pennsylvania Hospital) 14 were of the scapula, and of these 4 were of the acromion process. Out of 41 cases of fracture of the scapula collected by Dr. Agnew, 12 were of the acromion process.

Causes.—As the acromion process is the highest point of the shoulder all blows from above impinge upon it, and all violence occurring in consequence of falls on the shoulder, as well as violence transmitted through the arm, is expended at this point. Hence fractures of this process are caused by blows from above, by a fall on the shoulder, elbow, or hand, and by muscular contraction, as in a case reported in the *London Medical Gazette* for 1846. In this instance the fracture was caused by the sudden contraction of the deltoid muscle in raising the arm quickly.

Situation of Fracture.—The acromion process is generally broken at or internal to the acromio-clavicular articulation, near the junction of the epiphysis and diaphysis. The general direction of the fracture, according to Malgaigne, is transverse and vertical. Nélaton says, however, that it is generally oblique. If the fracture is at or internal to the acromio-clavicular articulation, there will generally be displacement of the outer end of the clavicle. In some cases merely the tip of the process is fractured off. In four cases seen by Dr. Hamilton the point of fracture was as follows: in two cases the bone was broken external to the acromio-clavicular articulation; in the third case the fracture extended into the articulation and was accompanied by dislocation of the outer end of the clavicle upward; in the fourth the fracture was in the same place, but there was no displacement of the acromion or the clavicle.

Diagnosis.—The signs of this fracture vary with the situation. In nearly all cases there will be crepitus, the false point of motion may be made out, and frequently the loss of continuity may be appreciated by passing the finger along the process. There will be distinct flattening of the shoulder with loss of power in the arm, as in fracture of the clavicle; the fragment being drawn downward with the arm. If there be no displacement the diagnosis will depend on crepitus and local tenderness; there will be partial loss of power in the deltoid muscle, which would become manifest after the patient attempts to raise his arm to the head. Erichsen says that when the clavicle is involved the flattening is more noticeable from behind.

Treatment.—Two forms of treatment have been recommended. The ordinary form is similar to that employed in fracture of the clavicle. The shoulder is raised by supporting the elbow in a sling, and a pad is placed in the axilla. A body-bandage binding the arm to the side will insure complete immobility. The other form, described by Dr. Hamilton, requires the patient to be kept in bed: the arm is then carried out at nearly a right angle with the body and retained in that position; by this method the fibres of the deltoid muscle are completely relaxed and the fragment allowed to remain in its natural position.

Prognosis.—Bony union is comparatively rare as a result of this injury; generally the union is ligamentous, with formation of a false joint; this is particularly the case with fractures of the tip of the process. When the fracture is external to the clavicle it generally unites with a slight downward displacement. When the acromio-clavicular articulation is involved, it is doubtful if complete reduction can be accomplished if there be dislocation of the clavicle. When the fracture is internal to the clavicular articulation, if much displacement exists, perfect readjustment will be difficult.

Separation of the epiphysis of the acromion process is no doubt the real injury in a great many cases of supposed fracture. As the centres of ossification for this process do not appear until the fifteenth or sixteenth year, and as ossification is not complete until the twenty-second to the twenty-fifth year, it seems very probable that in some cases of supposed fracture resulting in ligamentous union the separate parts had never completely united. Several pathological specimens confirm this opinion. (Holmes states that there is some unexplained connection between this imperfect ossification and chronic

rheumatic arthritis of the shoulder-joint.) The causes, symptoms, and treatment of this condition are the same as in fracture of the acromion process.

COMPOUND FRACTURES of the acromion process are of very rare occurrence, very few cases having been reported.

In one instance (Dr. H. N. Fisher, *New York Medical Press*, 1860), where the injury was inflicted by a moving crank striking the shoulder, a wound large enough to admit the finger was made, on exploring which it was found that the whole of the acromion process was fractured off, the deltoid muscle being torn from its attachment. The fragment of bone was removed, and the wound treated as an ordinary severe lacerated wound, a counter-opening being made posteriorly to allow of drainage. There was considerable sloughing, followed by healthy granulation. The patient was progressing favorably when the case was reported. No cases of *comminuted fracture* of the acromion are reported.

DISEASES.

The reported cases of disease of the acromion process are so few that it is evident that such disease is very rare indeed.

A case of caries was reported by Mr. Ferguson, in the *London Lancet* for 1843, the first manifestation being pain in the shoulder, followed by the formation of an abscess, which discharged itself and resulted in the formation of two sinuses, through which the probe passed to bare bone; there were also the usual signs of caries. Eventually both sinuses were laid open, and the entire acromion process was found to be carious and was removed, a large gap being left between the spine of the scapula and the outer end of the clavicle. The patient made a good recovery, with fair use of the arm, the outer end of clavicle and spine of the scapula being in close approximation.

Two cases of necrosis have been reported, one by Duplay and one by Friton. In the first case (*Bull. et Mém. de la Soc. de Chirurg. de Paris*) there was death of the entire acromion process, and also of a small portion of the outer end of the clavicle. The disease was first manifested by pain, swelling, abscess, and the formation of a fistulous tract; after an interval of some months resection was performed and the necrosed portion was removed. The patient recovered, with good use of the shoulder.

Diseases of the acromio-clavicular articulation are discussed under the head of Disease of Joints.

William H. Murray.

ACTINOMYCOSIS. This is an infectious disease, characterized by the appearance of new formations which are especially prone to undergo degeneration, and give rise to inflammation and suppuration in the surrounding tissues. The disease is most common in cattle and hogs; in man it is rare, not more than twenty or thirty cases of its appearance having been recorded. It is only in the past few years that actinomycosis has been recognized as a true specific disease. Bollinger described, in 1877, under this name, a disease of cattle chiefly marked by great swelling of the lower jaw. The swelling is due to the formation of large tumor-like masses, which seem always to originate in the alveolar process of the jaw, and by gradual growth to involve the neighboring tissues. The tongue is frequently attacked, and here numbers of nodular growths from the size of a walnut to that of a pea are found. Sometimes these nodules are single, at other times numbers of them are bound together by dense masses of connective tissue. Various names had before been given to designate this condition; it was called medullary sarcoma of the jaw, osteo-sarcoma, and was generally known simply under the name jaw sarcoma, and was thought to be a peculiar form of sarcoma only occurring here. It is due to the labors of Dr. W. T. Belfield, of Chicago, that we know the disease termed "swelled head," which is not uncommon in the cattle in the United States, to be identical with the disease Bollinger has named actinomycosis.

Bollinger described as peculiar to this disease certain yellowish seed-like bodies which were always found in the pus of abscesses and in the middle of the tumors. These were visible to the naked eye, and when rubbed between the fingers had a greasy feel. Microscropically, they were found to consist of threads similar to the ordinary mycelium, which terminated in bulbous ends (Fig. 58). Sometimes but one of these bulbs is connected with a thread, at other times there may be several. The forms which they assume are various; in many cases a filament is connected with a mass of bulbs which branch in every manner (*a*, Fig. 58). Apparently the highest type of development is seen in the mulberry-like body in Fig. 59, where all the filaments and bulbs seem to radiate from a common centre.

The nodules are found on microscopic examination to be composed of a great number of small masses not larger than miliary tubercles, which they greatly resemble. They are composed of small cells similar to the granulation tissue in the centre, and cells more spindle-shaped at the periphery. Each of these small masses is surrounded by a capsular investment of firm fibrous tissue. In the centre of each the fungous mass is seated, somewhat as the giant cell usually occupies the centre of the miliary tubercle. By the constant growth and agglomeration of smaller and larger tumors, masses as large as a man's fist and even larger than this are formed.

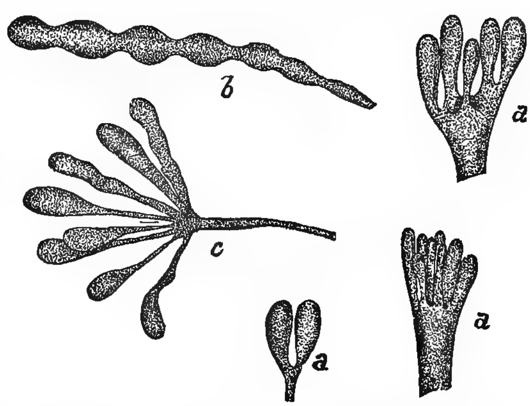

FIG. 58.—Various Forms of Actinomyces. (After Ponfick.) *a*, Peculiar formation of bulbs; *b*, beaded form; *c*, branching of bulbs from hypha.

Degenerative processes usually begin early, and destruction of the nodule by necrosis and suppuration takes place. Still the formation of new tumors keeps pace with the processes of decay; a termination of the disease in this way seems never to be brought about. Both in animals and man the disease usually begins in the alveolar processes of the jaw, and from here spreads along the base of the skull and the vertebral column. In man, the soft parts of the neck, the lungs, and chest-walls are often attacked. In consequence of the necrosis and attending suppuration abscess cavities and fistulæ are formed, in which the fungus is always seen. In the pus the recognition of the fungus is as easy macroscopically as microscopically. Here it appears in radiate masses like that shown in Fig. 59; these are about the size of a millet-seed and of a bright yellow color. The pus from these abscesses and fistulæ is always devoid of a fetid odor. The bones attacked are roughened, and an abundant formation of osteophytes takes place, leading to formations as bizarre as are seen after the maceration of an osteo-sarcoma. The disease spreads by gradual infection of adjoining parts. Metastasis seldom occurs, owing to the large size of the fungus and the difficulty of its entry into blood-vessels. Ponfick, however, mentions one very interesting case in which the tumor projected into the lumen of the internal jugular vein. In this case there was a metastatic growth about the size of an orange in the right auricle, and numerous metastases in the lungs.

The peculiar fungus associated with the disease has been named actinomyces, or ray fungus, from its peculiar manner of growth (as seen in Fig. 59). It occupies a place by itself and forms a distinct species, no other allied forms being known in botany. By some it has been placed among the bacteria, but more probably it comes nearer to the hyphamycetes, and the bulbous enlargements may be regarded as analogous to the conidia.

It may be regarded as the cause of the disease. Not only will inoculations with pieces of tissue or pus containing the fungus produce the disease, but it has been cultivated in suitable media outside of the body, and inoculations made with the product of a pure cultivation have been equally successful. Infection seems to take place, in most cases, from the buccal cavity. Israël, Johne, and Ponfick have found the fungus growing in the crypts of the tonsils and in concretions of the lachrymal duct, under normal conditions. It has also

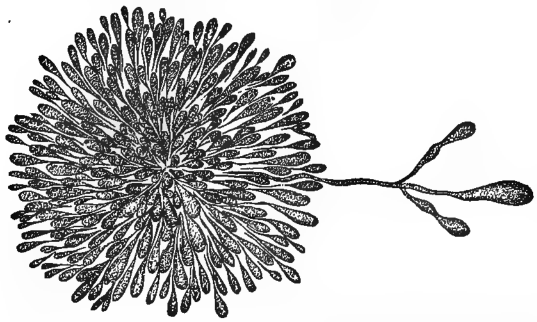

FIG. 59.—Perfect Form of Fungus. (After Ponfick.) A long filament terminating in bulbs is given off at one side.

been found in carious teeth. From these places it could easily be taken into the tissues by means of injuries of the mucous membrane or by the extraction of teeth. According to Israël, the fungus can be aspirated into the lungs, and infection may take place in this way. Among animals, the carnivora seem to enjoy an immunity. Outside of the body the fungus has never been found; most probably here it exists on various plants and green food.

The honor of having recognized the disease in man belongs to Ponfick. Israël published, shortly after Bollinger's publication, the account of two cases in man, but he regarded it as a peculiar form of septicæmia, and not as identical with the disease described by Bollinger. Up to the present, no case of its occurrence in man has been recorded in the United States, but judging from the frequency with which it occurs here in cattle it is probable that it has also, without being recognized, affected man. Clinically, it can always be detected by the presence of the yellow, seed-like bodies in the pus. *W. T. Councilman.*

ACTIVE PRINCIPLES. A name given to a great variety of substances, chiefly alkaloids and glucosides, existing in drugs, and to the presence of which the drugs owe their peculiar physiological and therapeutical action. Many of the active principles have been isolated and are employed medicinally—either in their basic form or in combination with acids as salts. They possess advantages over the crude drug for therapeutic purposes by reason of the smallness of the dose in which they can be exhibited, offering themselves especially for hypodermic use. But they do not always correspond in their effects to the plants or other drugs from which they are derived. A single plant, as, for example, opium, may contain a large number of active principles which produce effects upon the animal organism, varying among themselves both in degree and in kind. Hence in certain cases it is more desirable to exhibit some preparation of the crude drug rather than any single one of its isolated active principles. Or again, the active principle may be so active a poison that its administration is inconvenient or dangerous by reason of the extremely minute dose required.

Alkaloids.

The substances thus designated are natural organic bases, containing carbon, hydrogen, oxygen, and nitrogen, which possess an alkaline reaction and a bitter taste and which unite with acids to form salts. They are generally of crystalline form, though some, like nicotine, which contain only carbon, hydrogen, and nitrogen, exist as oily liquids. They are supposed to be substitution compounds of ammonia, but their chemical constitution is very complex and but little understood. They are for the most part derived from plants, though some are formed in the animal organism, and attempts have recently been made, with partial success, to produce them synthetically. They are, as a rule, the active principles of the plants in which they reside. Several may exist in the same plant, opium, for example, containing at least eighteen or twenty distinct alkaloids, which differ not only in chemical composition but also, more or less, in their effects upon the animal organism. The pure alkaloids are sparingly soluble in water, but soluble usually in alcohol, chloroform, and ether; their salts, however, dissolve with much more readiness in water. Most of the alkaloids used in medicine are active neurotic poisons, being either excitants or paralyzers of the nervous centres. The mode of action of the alkaloids is difficult of explanation. Rossbach believes that they render the cells incapable of taking up oxygen, and thus disturb their function; and possessing no affinity for the superficial tissues, as most of the other chemical poisons do, they are carried by the blood in a free state until they reach the nervous centres, upon which their force is expended. The names of the alkaloids terminate in English in *-ine;* in Latin the termination was formerly *-ia,* as morphia, atropia, but at the last revision of the U.S. Pharmacopœia in 1880 this was changed to *-ina,* as morphina, atropina, etc.

There is another class of substances derived from plants, many of which are similar in their action to the alkaloids, called *glucosides* or neutral principles. They are substances which, on boiling with a dilute acid, take up the elements of water and are split into sugar and some other compound, varying in each case with the glucoside used. They are distinguished in the Pharmacopœia of 1880 by the termination *-in* in English, and *-inum* in Latin. There are some other substances used in medicine which are commonly called by names having a terminology similar to that of the alkaloids, but which are very different both in their chemical composition and in their therapeutical action from this group of drugs. Thus podophylline is not an alkaloid, but is the resin of podophyllum, and what is usually called ergotine (of Bonjean) is the aqueous extract of ergot. There is also an alkaloid called ergotine, which, however, is not used in medicine. The employment of these incorrect terms should be avoided in prescribing.

The following is by no means a complete list of the alkaloids and glucosides, but includes only the more important members of these groups. Only the briefest mention is made of their physical characters and medicinal uses. For a full account of the physiological actions and therapeutical applications of these active principles, the reader is referred to the special articles treating of them or of the plants from which they are derived. The principal alkaloids are: Aconitine, apomorphine, atropine, caffeine, cinchonine, cocaine, codeine, daturine, hyoscyamine, morphine, physostigmine, pilocarpine, quinine, strychnine, and veratrine. The only glucosides that require any notice are digitalin, picrotoxin, salicin, and santonin.

Aconitine, $C_{30}H_{47}NO_7$, non-officinal, derived from the root of *aconitum napellus* and other varieties of aconitum. It exists in the form of a white amorphous powder, or of colorless rhombic crystals. It is used externally for the relief of neuralgia, especially of the fifth nerve.

Atropine, $C_{17}H_{23}NO_3$, officinal, prepared from *atropa*

belladonna. It exists in the form of "colorless or white acicular crystals, permanent in the air, odorless, having a bitter and acrid taste, and an alkaline reaction." It is usually exhibited in the form of the officinal sulphate. Atropine is employed to dilate the pupil for the purposes of ophthalmoscopic examination, and in the treatment of keratitis, conjunctivitis, and other affections of the eye. It is used externally to relieve superficial pain, and internally in neuralgia. It is one of the most effectual means which we possess to prevent the night-sweats in phthisis. It finds further employment in chorea, epilepsy, mania, and in nocturnal incontinence of urine. *Daturina,* an alkaloid of *datura stramonium,* and *Hyoscyamina,* derived from *hyoscyamus niger,* possess almost identical properties with atropine, and are occasionally employed for the same purposes. The sulphate of hyoscyamine is officinal.

Caffeine, $C_8H_{10}N_4O_2+H_2O$, officinal, exists in tea, coffee, guarana, and other plants. Occurs in the form of "colorless, soft, and flexible crystals, generally quite long, and of a silky lustre; permanent in the air, odorless, having a bitter taste and neutral reaction." It is employed as a cardiac stimulant and diuretic, being of especial value in many cases of cardiac dropsy. It also frequently relieves headache.

Cocaine, $C_{17}H_{21}NO_4$, non-officinal, derived from the leaves of *erythroxylon coca.* Occurs in the form of large colorless prismatic crystals, The hydrochlorate exerts a local anæsthetic and astringent effect, especially on the mucous surfaces. It is also a mydriatic. It is employed as a local anæsthetic in operations upon the eye, and also to reduce inflammation and relieve pain in conjunctivitis, toothache, earache, coryza, and gonorrhœa. It is likewise of value in superficial neuralgias, pruritus vulvæ, and many other affections in which an astringent and benumbing effect is desired.

Alkaloids of Cinchona.—There are several of these alkaloids used in medicine, but we need consider but two here. 1. *Quinine,* $C_{20}H_{24}N_2O_2$, officinal, derived from all varieties of cinchona, but existing in greatest proportion in *cinchona flava.* It occurs as "a white, flaky, amorphous, or minutely crystalline powder, permanent in the air, odorless, having a very bitter taste, and an alkaline reaction." The sulphate, bisulphate, hydrobromate, hydrochlorate, and valerianate are the officinal salts. Quinine has a very wide therapeutic application. It is employed in the treatment of malaria, septicæmia, neuralgia, and as a tonic, antipyretic, and microbicide. 2. *Cinchonine,* $C_{20}H_{24}N_2O$, officinal, exists in all varieties of cinchona, but in greatest proportion in the pale bark. Occurs in the form of "white, somewhat lustrous prisms or needles, permanent in the air, odorless, at first nearly tasteless, but developing a bitter after-taste, and having an alkaline reaction." Cinchonine possesses properties similar to quinine, but is weaker. It is employed as a substitute for quinine, chiefly on account of its cheapness. The sulphate is the officinal salt. The other officinal alkaloids of quinine are sulphate of cinchonidine, prepared chiefly from *cinchona rubra,* and sulphate of quinidine, derived principally from *cinchona pitayensis.*

Alkaloids of Opium.—This drug contains a very large number of alkaloids, of which, however, only three deserve special mention: 1. *Morphine,* $C_{17}H_{19}NO_3+H_2O$, officinal, occurs as "colorless or white, shining, prismatic crystals, or a crystalline powder, permanent in the air, odorless, having a bitter taste, and an alkaline reaction." The officinal salts are the sulphate, hydrochlorate, and acetate. Morphine is anodyne, antispasmodic, and hypnotic, and is employed in the relief of cough, asthma, diarrhœa, convulsions, to control vomiting, to relieve pain, and for a variety of other conditions. 2. *Codeine,* $C_{18}H_{21}NO_3+H_2O$, officinal. "White, or yellowish-white, more or less translucent rhombic prisms, somewhat efflorescent in warm air, odorless, having a slightly bitter taste, and an alkaline reaction." It is employed as a hypnotic, and to relieve cough, and is similar to, but weaker in its effects than morphine. It has been specially recommended in the treatment of diabetes. 3. *Apomorphine,* $C_{17}H_{17}NO_2$. The hydrochlorate is officinal. This is not a natural alkaloid existing in opium, but is prepared artificially from morphine by heating with concentrated hydrochloric acid. The salt occurs in "minute, colorless, or grayish-white, shining crystals, turning greenish on exposure to light and air; odorless, having a bitter taste, and a neutral or faintly acid reaction." It is employed hypodermically to produce emesis. Vomiting occurs promptly with little or no nausea. It is also highly recommended by some as an expectorant. In very small dose (0.0005 grm. = $\frac{1}{130}$ grain), it is said to control vomiting. Narceina, narcotina, papaverina, and thebaina, are other alkaloids derived from opium, which have been used to some extent in medicine; none of them is officinal. Thebaine is somewhat analogous in its effects to strychnine.

Physostigmine, $C_{15}H_{21}N_3O_2$, an amorphous, colorless powder, derived from *physostigma venenosum* or Calabar bean. The salicylate (officinal) and sulphate are the salts used in medicine. The officinal salt occurs as "colorless, shining, acicular, or short, columnar crystals, gradually turning reddish when long exposed to air and light; odorless, having a bitter taste, and a neutral reaction." It has been recommended in tetanus, but finds its principal employment in ophthalmology. It produces contraction of the pupil, thus opposing atropine. It is employed in the treatment of paralysis of accommodation, and in glaucoma to diminish intra-articular pressure, and to produce rupture of posterior and anterior synechiæ.

Pilocarpine, $C_{11}H_{16}N_2O_2$, derived from the *pilocarpus pennatifolius,* or jaborandi. The hydrochlorate is officinal. This occurs in "minute white crystals, deliquescent, odorless, having a faintly bitter taste, and a neutral reaction." Like the preceding alkaloid, pilocarpine causes contraction of the pupils. It increases very markedly most of the secretions of the body, especially those of the salivary and sweat glands. It is employed chiefly as a diaphoretic, in the treatment of uræmia, puerperal eclampsia, cardiac dropsy, and to promote the absorption of pleuritic exudations. Very small doses have been used to check the night-sweats of phthisis.

Strychnine, $C_{21}H_{22}N_2O_2$, officinal, derived from *strychnos nux vomica* or *strychnos ignatia,* occurs as "colorless, octahedral, or prismatic crystals, or a white crystalline powder, permanent in the air, odorless, but having an intensely bitter taste, which is still perceptible in highly diluted (1 in 700,000) solution, and of an alkaline reaction." The sulphate is the officinal salt. Strychnine is a tetanizing poison. It is employed in spinal and peripheral paralysis (when there is absence of rigidity), in the treatment of functional amaurosis, in constipation, prolapsus ani, in atony of the genital organ, and as a stomachic tonic.

Veratrine, $C_{37}H_{53}NO_{11}$, officinal, prepared from the seeds of *asagræa officinalis* or *veratrum sabadilla.* "A white or grayish-white, amorphous, rarely crystalline powder, permanent in the air, odorless, of a distinctive acrid taste, leaving a sensation of tingling and numbness on the tongue, producing constriction of the fauces, and highly irritant to the nostrils." Veratrine is not employed internally. It is used externally in the treatment of neuralgia of the fifth pair, of sciatica, and for the relief of rheumatic nerve-pains. The ointment and the oleate are officinal preparations.

Glucosides.

Digitalin, $C_5H_8O_2$, non-officinal, prepared from the leaves of *digitalis purpurea.* It occurs as small, white scales, or a yellowish-white powder. It is employed for the same purposes as digitalis, but possesses no advantages over the officinal preparations of this drug, and its use is not to be recommended.

Picrotoxin, $C_9H_{10}O_4$, officinal, prepared from the seeds of *anamirta paniculata* or cocculus indicus, occurs in "colorless, shining, prismatic crystals; permanent in the air, odorless, having a very bitter taste, and a neutral reaction." It is highly excitant of the medulla oblongata, accelerating and finally arresting respiration. It has been employed successfully to arrest the night

sweats of phthisis, and has also been recommended in certain varieties of headache and in epilepsy.

Salicin, $C_{13}H_{18}O_7$, officinal, prepared from the bark of *salix helix* and other varieties of willow, occurs in "colorless, or white, silky, shining crystals, permanent in the air, odorless, having a very bitter taste, and a neutral reaction." It is employed as an antipyretic and as a stomachic tonic, but its principal use is in the treatment of rheumatism.

Santonin, $C_{15}H_{18}O_3$, officinal, prepared from the unexpanded flower-heads of *artemisia maritima* (santonica), occurs in "colorless, shining, flattened, prismatic crystals; not altered by exposure to air, but turning yellow on exposure to light; odorless, and nearly tasteless when first placed in the mouth, but afterward bitter, and having a neutral reaction."

Santonin is employed as an anthelmintic. It causes the death and expulsion of round- and thread-worms, but has little effect on tape-worm. It is said also to be of value in amaurosis.

Thomas L. Stedman.

ACUPRESSURE. A procedure devised by Sir J. Y. Simpson, of Edinburgh, in 1859, for arresting hæmorrhage from a vessel by means of pressure made by a needle transfixed through the neighboring tissues. The flow of blood through an artery may be arrested in any one of three ways. The vessel may be simply compressed between the needle and some firm tissue, as a bone or the integument, as represented in Figs. 60 and 61. When the artery lies imbedded in a soft tissue, as in a divided muscle, its occlusion may be accomplished by torsion. This is done by introducing the needle on one side of the vessel, and, when it has passed through a portion of the tissue, twisting it around the artery and fixing its point in the tissue in a direction opposite to that in which it was first entered; or the artery need not be included in the bight of the needle, but the latter may be turned before reaching the vessel, the latter then being compressed by the elastic force of the twisted tissues acting upon the needle. A third method, applicable also in cases in which the vessel lies in a yielding tissue, consists in pressure between the needle and a slip-knot. The needle is passed beneath the artery, and a loop of fine wire is slipped over its point, the ends of the loop passing over the artery, and being fastened by two or three turns over the shaft of the needle (see Fig. 62). In the case of small vessels, the needles may be withdrawn at the expiration of twenty-four hours; but when large arterial trunks are occluded, the pressure should be maintained for forty-eight hours at least.

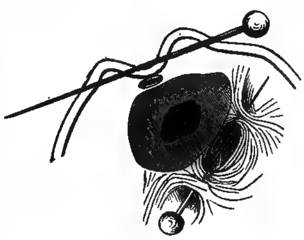

Fig. 60.

Fig. 61.

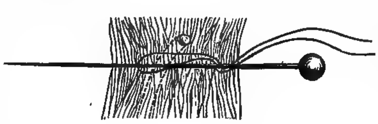

Fig. 62.

The advantages claimed for this method are: the ease and rapidity with which the needles may be applied, no delay being caused in the operation; the absence of danger from suppuration of the ends of the divided vessels, and non-interference with rapid closure of the wound, no inflammation being excited by the presence of the needles in the tissues for so short a period of time. These advantages, however, are less manifest at the present time, since the introduction and general employment of antiseptic ligatures, and it is not likely that the procedure will ever again enjoy the popularity which it at one time possessed.

Thomas L. Stedman.

ACUPUNCTURE. An operation which consists in the introduction of needles into the body, either as a means of giving exit to the fluid in œdematous tissues or for the relief of pain in neuralgia and muscular rheumatism. It is a method in great vogue in China, and is used by the physicians of that country not only to assuage pain, but to promote reparative action in ulcers and in the treatment of various other affections. It is said to have been introduced into Europe from China, by the missionaries in the seventeenth century. The instrument employed is a round polished needle, having a cylindrical handle of sufficient size to permit of its being readily manipulated by the fingers. It is introduced into the tissues by a quick rotatory movement, and is then left *in situ* for a number of minutes, or even for an hour. Sometimes the insertion of a single needle is sufficient to relieve the pain, but ordinarily half-a-dozen or more are employed. This little procedure may be practised almost painlessly, and is sometimes wonderfully effective in controlling neuralgic and rheumatic muscular pains. It often fails, indeed, and it seems impossible to determine beforehand in what cases it will prove serviceable, but certainly no case of lumbago or sciatica should be abandoned until acupuncture, as well as the more ordinary remedies, has been tried. In anasarca, when the scrotum and lower extremities are distended with fluid, the patient may experience comfort from a few punctures with a three-cornered surgical needle. The operation should be practised with caution, however, as it is apt to excite an erysipelatous inflammation of the integument. In the treatment of paralysis insulated needles are sometimes used as a means of introducing the electric current into the deeper tissues. This procedure has received the name of *electro-puncture.*

There is another form of acupuncture, called *Baunscheidtismus*, which at one time enjoyed a great popular reputation, and which even now is not very infrequently employed. It was devised by a German named Baunscheidt, who is said to have conceived the idea from observing that the irritation caused by the bites of insects afforded him considerable relief from the pain of an articular affection from which he was suffering. The instrument employed consists of a cylinder enclosing a button into which are inserted from twenty to thirty short needles. The open end of the cylinder is placed on the integument, and then by means of a handle the button with needles attached is drawn up into the cylinder compressing a spiral spring; when the handle is released the force of the spring impels the needles suddenly and sharply into the skin. The operation may rest here, or an irritating fluid, such as mustard-water or cajeput oil, may be applied to the punctures. This is employed for the relief of neuralgia and muscular pains, and often proves of very great service.

There is still another form of acupuncture, if such it can be called, though it is more nearly related to hypodermic medication. It consists in the hypodermic injection of pure water, and has received the name of *aquapuncture.* Many superficial pains, even though quite severe, may be relieved by this simple procedure. That the relief thus obtained is not merely the effect of imagination, is evidenced by the fact that neuralgias of distant parts are not benefited by aqueous injections, but in order to be effectual the operation must be practised at a point as near as possible to the seat of pain. Aquapuncture is employed in various forms of neuralgia, in lumbago, and in painful functional affections of the abdominal viscera. Bartholow states that he has obtained excellent results from the injection of water into the substance of paralyzed and atrophied muscles. From two to four grammes (one-half to one drachm) of fluid may be used for each injection, and the operation may be repeated if no relief is experienced at the expiration of two or three minutes. *Thomas L. Stedman.*

ADAMS COUNTY SPRINGS, Ohio. The springs are situated in a picturesque region of Southern Ohio, seventy-five miles east of Cincinnati, and thirty miles west of Portsmouth. The name of the nearest station, on the Cincinnati & Eastern Railroad, is Mineral Springs.

Analysis.—A qualitative analysis by Prof. E. S. Wayne states there are fifteen grains of solid matter to the pint, composed of chloride of magnesium, sulphate of lime, carbonate of lime, chloride of sodium, chloride of calcium, and oxide of iron. The water is a chalybeate, and has a temperature of 56° F. (Walton.) *G. B. F.*

ADAMS SPRINGS. *Location and Post Office,* Glenbrook, Lake County, Cal.

Access.—By railroad from San Francisco to Calistoga, seventy-three miles, thence by stage to Glenbrook, twenty-three miles, over an excellent road, where teams from the hotel meet the stage to convey guests to the springs, three miles distant.

Analysis. One pint contains:

Solids.	*Grains.*
Carbonate of lime	3.589
Carbonate of magnesia	12.378
Carbonate of soda	7.129
Carbonate of iron	.064
Chloride of sodium	.514
Silica	.902
Organic matter	.351
Nitric acid	traces.
Salts of potash	"
Total	24.927

Carbonic acid gas, 38 cubic inches.

Therapeutic Properties.—This is a valuable alkaline water, diuretic and purgative, and has proved very useful in kidney and liver diseases, dyspepsia, and aggravated cases of constipation.

These springs are located in the pine mountains of Lake County. The geological formation of the surrounding country is soft granite, in which are embedded veins of slate, iron, and gravel. The spring issues from a deposit of blue clay and gravel. The climate is salubrious, with a mean temperature of 85° F. in summer and 15° to 20° above zero in winter. The average annual rainfall is twenty-five to thirty-five inches. Accommodation is supplied by the Adams Springs Hotel and cottages, having a capacity for forty people. Pure and soft drinking-water is brought to the hotel by pipes from a distance of one mile. The neighborhood is covered with pine forests. Game, such as grouse, quail, hare, and deer, furnish amusement for the sportsman. Clear Lake, eight miles distant, stocked with various kinds of fish, and the creeks full of trout, give occupation to the lovers of the piscatorial art.

History.—The springs are said to have been discovered accidentally eighteen years ago, by a man named Adams, travelling in search of health. He was suffering at the time from "liver disease," and, having been cured by the water, he spread the fame of these springs.

George B. Fowler.

ADDISON'S DISEASE (Bronzed Skin Disease; Melasma Supra-renale). Of the above terms the first is to be preferred, for while the peculiar discoloration of the skin is not an invariable characteristic of the affection, the credit of Addison to the discovery of the disease called by his name has never been called in question.

Definition.—A disease characterized by progressive asthenia, digestive disorders, pain and tenderness chiefly seated in the epigastrium, hypochondria, and lumbar regions, and an abnormal pigmentation of the skin and mucous membranes.

Historical Notice.—The first case of Addison's disease on record is to be found in Lobstein's treatise, "De nervi sympathici humani fabrica et morbis," Paris, 1823, from the English translation of which, by the late Professor Joseph Pancoast, I take the following extract: "I have myself observed the nerves forming the suprarenal plexus, much thicker in disease, where the capsulæ renales, which were more than twice as large as usual, had degenerated into tuberculous substance." The patient was an unmarried woman, twenty-five years of age, who died in "convulsive spasms analogous to the epileptic. . . . Nothing unusual was discovered in the body of this woman but the aforesaid change in the suprarenal glands, and the enlargement of the nerves."

Notwithstanding the fact that there is no record of any darkening of the complexion, the above was undoubtedly a typical case of Addison's disease, in which, moreover, death by convulsions is not uncommon. The observation regarding the thickening of the nerves in this, the first recorded instance of the disease, is of remarkable interest. The second case was recorded in the "Halle Hospital Reports" by Dr. Schotte, in October, 1823, and is published in volume vii. of the *Deutsches Archiv f. klin. Med.* by Risel, in the course of his article "Zur Pathologie des Morbus Addisonii." The third case came under the observation of Dr. Richard Bright at Guy's Hospital, in July, 1829. It is contained in Dr. Bright's classical "Reports of Medical Cases," and also figures as Case V. in Addison's original memoir. The lesions of the capsules were characteristic; there was no other affection of any consequence, and for the first time in the history of this disease it was noted that the "complexion was very dark." A few other cases were reported before the year 1855, when Addison published his work "On the Constitutional and Local Effects of Disease of the Supra-renal Capsules," but it was reserved for his sagacity to detect the relation between the well-marked constitutional symptoms of the affection, the peculiar pigmentation of the skin, and the structural changes in the suprarenal capsules.

It is no disparagement to the memory of Addison to say that the general acknowledgment of his discovery has been retarded by his including in his treatise cases which, at the present day, would be rejected from the category of Addison's disease. Of his eleven cases there are but four uncomplicated with other affections, two complicated, while of the remaining five, one was a case of softening of the brain with advanced kidney disease and tubercular deposit in various organs, among others in one suprarenal capsule, and the other four were cases of widespread carcinomatous deposit, the suprarenal capsules being more or less involved in each. Addison was evidently under the impression that the symptoms of the disease were due to the suppression of the unknown function of the suprarenal capsules, and that, therefore, any destructive lesion of these bodies was capable of causing them, but it is now established that they are invariably associated with one particular lesion, to be described under the head of the Anatomical Characters of the affection.

Anatomical Characters.—The lesion of typical cases of Addison's disease is a primary, chronic, interstitial inflammation of the suprarenal capsules, beginning in the medullary substance in the form of gray granulations precisely resembling those of tubercle, which enlarge, coalesce, and undergo caseous degeneration. The inflammation extends to the cortical substance, and finally obliterates all traces of the primary structure of the organs. The fibrous investment alone resists destruction. It becomes much thickened through an inflammatory hyperplasia, and contracts adhesions with neighboring organs, such as the kidney, liver, diaphragm, pancreas, etc. Under the microscope the process is seen to consist of a small-celled infiltration of the connective tissue septa of the organ, which partly develops into fibrous tissue, while the remainder undergoes caseous degeneration. The latter change occurs in the form of nodular masses varying from the size of a pea to that of a pigeon's egg, which are at first dry, then undergo puriform softening, and, later, through the absorption of their fluid portions, become converted first into putty-like, and finally into calcareous masses. These last changes are accompanied with much shrinking of the previously greatly enlarged organ. The puriform fluid of the stage of softening has precisely the naked-eye appearance of pus, but under the microscope is seen to consist of granular detritus and oil-globules. The gross ap

pearances correspond with the stage of the disease. There is no case on record in which the morbid deposit could be said to be at its earliest stage in any portion of the capsule. In those cases in which the anatomical alterations are least advanced, the suprarenal capsules are enlarged, indurated, and nodular, the enlargement sometimes equalling that of the subjacent kidney, as in a case of my own, recorded in the tenth volume of the "Transactions of the Pathological Society of Philadelphia." On section of such an enlarged capsule it is seen to be composed of a grayish, semi-translucent substance, in which are imbedded irregular roundish masses of a yellowish color and friable consistence. At a later stage, the yellow nodules soften and the organ is honeycombed with cavities containing the puriform fluid above mentioned. The last stage is that of absorption of the fluid contents of the altered organ and the deposit of cretaceous matter, with coincident shrivelling to a size perhaps below the normal. As to the exact nature of the morbid process, authorities are united in considering it an inflammation which they variously qualify as strumous, tubercular, or caseous. These terms are one and all appropriate, conveying, as they do, to the minds of all pathologists the idea of an abundant infiltration of cells of low vitality, which partly become organized into fibrous tissue and partly undergo caseous and puriform degeneration. The affection is generally bilateral, although Risel (*Deutsches Arch. für klin. Med.*, vol. vii., 1870) has reported two cases, in each of which the left capsule only was involved.

Of equal interest with the morbid changes in the suprarenal capsules are certain alterations in the neighboring nerves and ganglia, of which mention has been made in a number of cases. The significance of these lesions of the nervous system is impaired by the fact that they are not invariably found. Eulenberg and Guttmann (*Journal of Mental Science*, January, 1879) have collected twenty cases in which well-marked lesions of the suprarenal plexus and the ganglia and nerves of the solar plexus were found, opposed to which are twelve cases in which careful examination demonstrated no change whatever. The positive observations include fatty degeneration of the semilunar ganglion and solar plexus, first observed by Queckett in one of Addison's cases; swelling and redness of the nerves of the lesser splanchnic and ganglia of the solar plexus, atrophy, pigmentation of ganglionic cells, increase of connective tissue in the ganglia and in the neurilemma of the nerve-fibres; and, finally, suppuration and caseation of the semilunar ganglia.

Notwithstanding the above-mentioned negative examinations, it is the opinion of the writer that the abdominal sympathetic is functionally impaired in every case of Addison's disease. This question will be more fully discussed under the head of the Pathogeny of the disease.

Enlargement of the mesenteric and retro-peritoneal glands is frequently observed. In one of my own cases it is recorded that the "mesenteric glands were greatly, and the lumbar glands enormously, enlarged" ("Path. Soc. Trans., Phila.," vol. x.).

More or less gastro-intestinal hyperæmia and catarrh, with enlargement of the solitary and agminated follicles, are present in every case. A mammillated condition of the gastric mucous membrane was observed by Dr. Hodgkin in one of Addison's cases. Ecchymoses and hæmorrhagic erosions of the gastric mucous membrane are sometimes present. Enlargement of the spleen is occasionally observed; also an abnormally dark color of spleen, liver, kidneys, and pancreas, and brownish hue of the peritoneum. These lesions are due to long-continued hyperæmia of the abdominal organs. This hyperæmia is sometimes evident at the necropsy, as in the case of my own last referred to, in the report of which it is noted: "The blood was fluid, and on removing the liver it poured out of the inferior vena cava in large amount. There was none of the dryness and translucency of tissue so constantly met with in severe cases of anæmia."

Many of the symptoms of Addison's disease are attributed by writers to a high grade of general anæmia, without any evidence in favor of such an opinion. In several of Greenhow's cases the blood was examined microscopically with "virtually negative results." In another case, under the care of Dr. Bristowe, Greenhow examined the blood, and found it "rich in red globules." Wilks states positively that anæmia is not present. These statements require some modification. In many cases of Addison's disease, especially those complicated with pulmonary tuberculosis, there is a high degree of anæmia, although not to be compared with that found in cases of progressive pernicious anæmia, and in almost all cases I am confident that a careful enumeration of the red globules would demonstrate their deficiency. Long-continued intestinal hyperæmia invariably leads to anæmia, as is commonly seen in the cachexia of heart disease, the *cachexie cardiaque* of Andral. An increase in the number of the white cells has been observed in several cases, but as no figures are given, it is impossible to say how near the condition approached that of leucocythæmia. Free pigment is said to have been found in the blood in one case, by Van den Corput. Dr. W. E. Hughes, of Philadelphia, kindly sent me the following notes of his examination of the blood of a case of Addison's disease; the patient left the city, and the diagnosis, which was based upon the presence of all the characteristic symptoms of the disease, was never confirmed by a necropsy:

"Addison's disease, two years' duration. Pigmentation of skin and mucous membrane of mouth; no emaciation; moderate anæmia; great weakness. Red corpuscles, 5,130,000; white corpuscles, 9,000 per cubic millimetre. Red are a little below normal in size and a trifle pale, well shaped; some few are deeply pigmented, the pigment granular. Floating free in the blood-plasma are irregular granules of black pigment, from one to four times the size of red corpuscles. They are not at all numerous, not more than two in field at one time; sometimes not more than two on the slide."

The abnormal surface pigmentation has its seat in the skin and mucous membrane of the buccal cavity, including that of the tongue; it has been said also to attack the vagina, but this is not established. The pigment is deposited in the youngest layers of the rete Malpighii, in contact with the papillæ. It appears both as a diffuse coloration of the cells and also in the form of distinct granules in the cells, or free; in the latter case it is supposed to be left after the dissolution of the cells. It rarely appears in the corium, though sometimes branched, pigmented connective-tissue cells are found. The parts of the external surface most deeply pigmented are those which, under normal circumstances, are the seat of oft-recurring hyperæmia, either from atmospheric influences or friction, such as the cheeks, neck, and backs of the hands. There is also a special tendency to the deposit of pigment in those parts where it is found normally in greater amount, such as the nipples, genital organs, and axillæ. In well-marked cases, it pervades the entire cutaneous surface, being deeper in the parts just mentioned. The discoloration, at first of a grayish hue, deepens into a more or less deep brown, in which there is, in some cases, a yellowish or greenish hue. The color depends to some extent upon the normal complexion of the patient. It is most striking, on account of its incongruity, when the patient is naturally fair, with light hair and blue eyes. It has been noted in numerous cases that the heart was abnormally small, and in several that it had undergone fatty degeneration.

The urine is normal in the majority of cases. The most careful study of the urine in any single case was made by Dr. Thudichum, for sixty-five consecutive days, in a patient of Dr. Burdon-Sanderson. Without complicating fever or diarrhœa, there was a great diminution in the daily amount of urine, it being reduced more than one-half; the specific gravity was 1.020, and upward, and the reaction acid. The observations were chiefly directed toward the determination of the percentage of uric acid as well as uromelanin, omicholin, and uropittin, three products of decomposition of the urinary pigment of which the first is the most important.

It has almost the same chemical composition as the melanin of the choroid, and of melanotic tumors, and, like the pigment in the skin in Addison's disease, is iron-free. Thudichum found that these pigments were greatly reduced in amount, the uromelanin never rising above one-twelfth of the normal, and he appears to be of the opinion that the diminution in the amount of these pigments may be in relation to the excess of pigment in the skin.

Symptoms.—The sum of the symptoms of Addison's disease may be divided into four parts: a progressive asthenia, disorders of digestion, an abnormal pigmentation of the skin and oral mucous membrane, and pain seated chiefly in the lumbar and abdominal regions. Of these, the asthenia is the first to appear. In all histories of this disease the patient has been compelled to abandon his usual occupation by muscular weakness, and where there is no complication with other wasting disease, this prostration is unattended, at least in the early stage, with any marked diminution in the volume of the muscular and adipose tissues. Symptoms referable to disordered digestion soon become prominent, such as anorexia, nausea and vomiting, constipation alternating with diarrhœa, and epigastric tenderness. Cardialgia is often complained of, and the ingestion of food is sometimes followed by painful meteorism. The pulse is remarkably weak and small, and usually slightly accelerated. Dyspnœa is produced by the slightest exertion such as sitting up in bed. Cephalalgia, vertigo, and mental hebetude are often observed at an early stage, also pain and tenderness in both hypochondria, and in the back, loins, and epigastrium. This tenderness on pressure was a prominent feature in two cases that were under my care at the Episcopal Hospital, Philadelphia. In the report of the first I noted that "at times there was great tenderness about the umbilical region, and on one occasion, after palpating the abdomen, the patient uttered loud cries for ten or fifteen minutes, and seemed in great agony" ("Trans. Path. Soc., Phila.," vol. v.). In the second of my cases, "the pain was latterly most severely felt in the left lumbar region, in which situation there was also a great degree of tenderness on pressure" ("Trans. Path. Soc., Phila.," vol. x.). In the first of these cases nothing was found at the necropsy to account for this remarkable tenderness; in the second it might have been due to the great tumefaction of the lumbar glands. As the disease progresses, restlessness, jactitation, delirium, sometimes maniacal, delusions of sight and hearing, attacks of epileptiform convulsions, and uncontrollable vomiting make their appearance; also attacks of prolonged prostration and loss of consciousness; sometimes a condition of collapse that has been compared by Wilks to that of cholera. Contrary to the usual frequency of the pulse in collapse, a remarkable diminution in the number of the heart-beats has been observed in several cases (Risel mentions seven), and this without any disease of the brain or important cardiac disease. In a case reported by Cholmeley (*Medical Times and Gazette*, 1869, vol. ii., p. 219) in which death was preceded by profound collapse, dyspnœa, and convulsions, the pulse fell to thirty-six per minute. The date of the appearance of the pathognomonic discoloration of the skin is very variable. It may either precede or follow the constitutional symptoms, or the disease may terminate fatally without its manifestation. Greenhow has collected a number of cases illustrating the erratic appearance of this, the only pathognomonic feature of Addison's disease. In many cases the symptoms have pursued an irregularly remittent course. The digestive disorders may temporarily cease, the appetite improve, the muscular power increase, and the skin become decidedly paler. This is invariably followed by a fresh exacerbation, after which the status of the patient is on a lower plane than during the previous remission. The words of Dr. Weir Mitchell, as applied to the course of locomotor ataxia, are here appropriate: "I have," says he, "elsewhere compared the progress of Duchenne's disease to that of a man who has an inevitable staircase to descend. He may linger or go back, but the descent is still to be taken, and the best he can hope for is to go down slowly and with long pauses and rare retrogressions" ("Proceedings Phila. County Med. Soc.," vol. ii.).

PATHOGENY.—The symptoms of Addison's disease being invariably associated with a destructive lesion of the suprarenal capsules, were at first naturally attributed to suppression of the function of these bodies. Brown-Séquard first endeavored to ascertain the effect of removing the capsules from animals. The animals speedily died with, according to his statement, the accumulation of pigment in different parts of the body. On the other hand, a number of other experimenters, such as Harley, Gratiolet, Philippeau, and Martin Magron, have removed the suprarenal capsules without the supervention of death or melanoderma. Again, well-marked cases of Addison's disease have been observed, as above stated, in which but one capsule was involved in the morbid process. Finally, instances are on record of congenital absence of the suprarenal bodies [1] without the cutaneous pigmentation or other symptoms of Addison's disease. The attention of pathologists was next directed to the ganglia and nerves of the abdominal sympathetic, and experiments instituted upon animals to determine the effect of their removal or section. Pincus invariably found, after extirpation of the solar plexus, alterations in the mucous membrane of the stomach and upper part of the small intestine, consisting of hyperæmia, blood extravasation, and ulceration. These were absent in control experiments, in which the same operation was performed minus the removal of the solar plexus. When the deeper plexus encircling the aorta was removed, the alterations in the mucous membrane of the stomach were absent, but the whole of the small and large intestine, including the rectum, was affected. Enlargement of the liver and spleen was also observed by Budge after section of the abdominal sympathetic. With the results of these experiments corresponds the invariable intestinal catarrh of Addison's disease, with enlargement of the solitary and agminated glands, and sometimes ulceration and ecchymosis. The theory of the pathogeny of Addison's disease at present accepted by many authorities, notably by Risel, and the one to which I adhere, is that of a paralytic dilatation of the abdominal blood-vessels, and it is not necessary that there should be a destructive lesion, such as fatty degeneration or atrophy, of the solar plexus and semilunar ganglion, in order to produce vaso-motor paralysis in the area of their distribution. Irritation of a sensory nerve produces vaso-motor paralysis in the irritated region, and the well-known experiments of Goltz [2] (Klopfversuch) have shown that irritation of the intestines produces complete vaso-motor paralysis of their blood-vessels, causing thereby so great an accumulation of blood that the animal shows symptoms of syncope, the same as if it had been bled copiously.[3] The irritation of the numerous nerves of the suprarenal capsule produced by inflammation with new formation of tissue and subsequent softening, such as exists in Addison's disease, is transmitted to the semilunar ganglion and solar plexus from the beginning of the deposit in the medullary substance of the suprarenal capsule, and later by direct extension of the inflammatory process to these nerve-centres. By this means a vaso-motor paralysis of the intestinal vessels is produced, as in the experiments of Goltz, except that, unlike in the latter case, it is constant. This constant hyperæmia of the intestinal vessels leads to enlargement of the solitary glands and Peyer's patches so constantly found in Addison's disease, and, when more intense, to catarrh and ulceration of the stomach and intestinal mucous membrane. It accounts for the dark color of the liver, spleen, kidneys, and pancreas so often observed, as well as for the brownish hue of the peritoneum noted in a few instances. Indirectly it explains the anæmic and dry condition of other parts of the body, and fully accounts for the great muscular weakness, syncope, gastro-intestinal disturbance, dyspnœa on slight exertion, and small radial pulse. These symptoms have been, and still are, attributed to a high grade of general anæmia, such as exists in progressive pernicious anæmia; and this is due to the fact that many of the symptoms in these two affections are identical. Repeated examinations of the blood have, however,

demonstrated that the reduction in the number of the red corpuscles in Addison's disease is trivial compared with that found in cases of progressive pernicious anæmia. The symptoms resembling those of pernicious anæmia, such as dyspnœa on slight exertion, syncope on assuming the upright posture, rapid, small, and feeble pulse, are due to an insufficient supply of blood, albeit of fair quality, to the supra-diaphragmatic portion of the trunk. The permanent changes in the muscular tissue of the heart are to be attributed to the same cause, oligæmia.

ETIOLOGY.—The affection is much more common in the male sex and among the laboring classes. In one hundred and eighty-three undoubted cases tabulated by Greenhow, one hundred and nineteen were males and sixty-four females, and more than nine-tenths of the whole number were engaged in laborious physical work. Several cases have been associated with psoas or lumbar abscess, caused by injuries of the spine. In others, devoid of such spinal complication, the origin of the disease has been attributed by the patient to over-exertion of the spinal muscles. Such was the fact in one of my own cases, the patient's first symptoms having been weakness and pain in the back immediately following the occupation of weeding her garden. As regards age, the majority of cases occur between the ages of twenty and fifty, that is to say, during the most active period of adult life.

DIAGNOSIS.—When the disease is primary, the constitutional symptoms well-marked, and the discoloration of skin present, the diagnosis presents no difficulty to one who has studied a single case of the disease. On the other hand, when the constitutional symptoms are well pronounced in a primary case, and the bronzing of skin not yet developed, the diagnosis is only to be made by the absolute exclusion of other wasting diseases, especially cancer of abdominal organs and progressive pernicious anæmia. When the disease is secondary to psoas or lumbar abscess, the diagnosis is often very difficult, and especially so when there is the further complication of amyloid kidney disease which is so apt to be associated with extensive suppuration. Several years ago there came under my care at the Episcopal Hospital, a case of lumbar abscess with several open sinuses leading to carious vertebræ. The general surface of the body was of a dark, dingy hue, and the orifice of each sinus was surrounded by a broad, deeply pigmented ring. The case had previously been at the University Hospital, where secondary disease of the suprarenal capsules had been suspected. The autopsy showed these bodies to be perfectly normal. A dingy discoloration of the skin is not uncommon in amyloid disease of the kidney, as first pointed out by Grainger Stewart.

The discoloration of skin, although not the most essential characteristic of the disease, is justly regarded as its most important diagnostic feature. It is to be distinguished from melasma gravidarum, pityriasis versicolor, lichen, and pigmentary syphilides, and this is readily done by anyone familiar with these affections. The melanoderma of phthisical patients presents more serious difficulty. Although the latter is often confined to the face and does not invade the mucous membrane of the buccal cavity, the difficulty is a real one and is augmented by the fact that pulmonary tuberculosis is the most frequent complication of Addison's disease. The seat of the melasma suprarenale upon the face and neck, the dorsum of the hands, areola of the nipple and about the umbilicus, in the axilla, groin, and genitals is characteristic. Its outline is never circumscribed as in other pigmentary affections, but gradually fades into the surrounding dingy integument. Upon the darker patches also are frequently seen black specks resembling moles or freckles. Another discoloration of the skin liable to be confounded by the inexperienced with that of Addison's disease, is sometimes seen in badly nourished paupers, of dirty habits, whose skin is the abode of vermin. The pigmentation shows itself in the form of patches separated by healthy skin; the epidermis is often roughened, and the discoloration more marked upon the trunk than on the face and hands. The skin is also often marked with the nails on account of the intense itching. Under the microscope, the particles of pigment in this affection are found in all the layers of the epidermis, instead of being limited, as in Addison's disease, to the deeper layers of the rete Malpighii. The pigmentation of chronic malarial poisoning is distinguished from that of Addison's disease, not only by its distribution, but by the history of the case and the frequent presence of splenic enlargement. Chronic icterus is distinguished by the presence of pigment in the ocular conjunctiva and in the urine. The pulse also is rapid in Addison's disease, whereas in icterus it is habitually slow.

PROGNOSIS.—The prognosis is invariably fatal as to the ultimate result, but the occasional remittent character of the affection is to be borne in mind in making predictions as to the duration of the disease. A case seen during the period of exacerbation may lead to the prognosis of a speedily fatal result, but the worst symptoms may disappear and be followed by a prolonged period of remission. Sudden death without preceding exacerbation is sometimes observed, the fatal result being apparently due to syncope.

TREATMENT.—The cessation of work is the first thing to be insisted upon in the way of treatment, and during the exacerbations, strict confinement to bed. An immediate mitigation of the symptoms has often followed the admission to the hospital of a patient who, up to that time, had been endeavoring to resist the gradually increasing weakness. A moderate amount of stimulants is generally well borne; but cod-liver oil, which might seem appropriate on account of the strumous character of the affection, is, as a rule, not tolerated. Remedies to allay irritability of the stomach are frequently indicated, such as ice, lime-water, carbonic acid water with brandy, bismuth, creasote, hydrocyanic acid, and small doses of opium. Massage and faradization of the cutaneous surface are well worthy of a trial, in order to derive from the abdominal vessels. Cathartics are to be avoided, as profound depression has often followed their employment in this disease. When constipation is troublesome, enemata are to be made use of. The diet should be simple, but nourishing, consisting of soups, milk, eggs, meat jelly, and the like. Peptonized foods and koumyss are also indicated.

Frederick P. Henry.

[1] Martini: Comptes Rendus de l'Acad. des Sci., 1856, tome xliii., p. 1052. John Kent Spender; Brit. Med. Jour., September 11, 1858.

[2] Vagus und Herz., Virchow's Archiv, vol. xxvi.

[3] "Il en résulte une dilatation des vaisseaux abdominaux qui constituent en quelque sorte un bassin de réserve ou de dérivation pouvant loger la moitié de la masse totale du sang" (Demontrond, Thèse de Paris, 1878).

ADELHEIDSQUELLE. This spring is situated in Upper Bavaria, at an elevation of 774 metres (2,540 ft.), near the foot of the "Benedictenwand," and about four miles from the station Tölz. The water is mostly bottled for export. It is used internally, and has acquired renown for its beneficial effects in cases of scrofula (in children), in glandular swellings, struma, chronic metritis, and oöphoritis, and in tumors of the female sexual organs. Von Nussbaum speaks of the water in very high terms; it having produced markedly beneficial effects in some of the worst cases of scrofulous bone disease which had come under his care. Among one thousand parts of this water, by weight, the solid constituents represent a total of 6.01 parts, and among these the most important are:

Sodium chloride	4.956
Sodium iodide	0.0286
Sodium bromide	0 0478
Sodium carbonate	0.0809

(Carbon dioxide, 409.3 c.c.)
Temperature, 11.2° C. (52° F.). (Eulenburg.)

H. F.

ADENOMA. The adenoma is a glandular tumor, conforming, in its histological structure, with the general type of gland-tissue, and originating in glandular epithelium. We cannot describe any particular cells or arrangement of cells as peculiar to this tumor any more than we can regard any special cells as peculiar to physiological glandular structure. The adenomata differ

among each other in structure as much as the structure of the liver differs from that of the lachrymal gland. Generally speaking, the epithelial cells of the tumor are arranged in alveoli, with a central lumen, the alveoli being separated from each other by connective tissue, in which the nutrient vessels and lymphatics are contained. The epithelial cells may be cylindrical or cuboidal, their shape depending somewhat on the character of the cells of the gland in which the tumor has originated. Their arrangement in alveoli, with a central lumen, may be regarded as that which gives the adenoma its character.

We cannot regard every new formation of glandular tissue, every glandular hyperplasia as an adenoma, and sometimes it is difficult or impossible to say whether we have to do with a simple hyperplasia or a tumor. Nature does not create with special reference to the classification of her products, and we come here into the difficulty which is constantly met when we attempt to bring such products under an artificial classification. A gland which is increased in size in consequence of excessive growth or a chronic inflammatory condition, cannot be called an adenoma, but belongs simply to the hyperplasias. In the same way we must consider those formations in mucous membranes which frequently develop in consequence of chronic inflammations, and take the form of tumors. These are local new formations of tissue, which project above the surfaces in the form of polypi or papillary masses. This growth commences in the connective tissue, and the epithelium also takes part, in that, by the increase of the surface, the covering epithelium must also increase. If there are glands present, their ducts are usually stopped up, and cysts are formed with papillary projections within them. On the other hand, there are adenomata which arise in the mucous membranes and which have the form of polypi, and may greatly resemble the simple polypi in structure. Clinically, of course, the two processes can be distinguished, since the simple polypi are usually multiple, and disappear spontaneously when the cause which led to their formation (*i.e.*, chronic inflammation) is removed. The separation of the adenomata from many other tumors is often difficult. If the development of glandular vesicles with formation of cavities must be regarded as the essential moment to justify us in naming a tumor an adenoma, this development cannot take place without the formation of new connective tissue with vessels. Since the pathological features of a tumor only consist in the variation of the arrangement of its tissue from that of the normal tissue, we find in the adenoma that at one time the formation of the epithelial elements becomes most prominent, at another that of the connective tissue and vessels. Mixed forms are here common. When the development of connective tissue is excessive, far beyond what we find in a normal gland, it must receive some recognition in naming the tumor, for it is as truly new-formed as the epithelial part; in such cases we speak of an *adeno fibroma*. When this newly formed connective tissue is especially abundant in cells, and represents an embryonic tissue, we speak of an adeno-sarcoma.

Though the adenoma may have the most typical glandular structure, it is always, when considered as an entirety, an atypical formation. As a rule it represents a circumscribed formation and macroscopically differs in consistence and color from its surroundings. These growths usually form nodular tumors, which arise within glands or in mucous membranes which contain glands. In some cases only a small portion of the gland is taken up by the tumor, in others the whole is involved in its growth. The adenoma usually differs in its histological structure more or less from the structure of the tissue in which it originated. This is well seen in the figure here given, which represents an adenoma of the kidney. Nothing could be more typical of glandular structure than the tumor, yet instead of the typical kidney structure with its various tubules and special structures, as the glomeruli, we have here simply the structure of a tubular gland, the tubules being of different sizes and lined with a simple cuboidal epithelium. The tumor from which the specimen was taken was of the size of a walnut, located in the left kidney, and entirely surrounded by normal kidney structure, from which it was separated by a distinct capsule of connective tissue. In other adenomata of the kidney we may find, in place of the cuboidal, long cylindrical cells. In one that I examined, which came from the collection of Rokitansky, the cells were cylindrical in shape, and differed greatly in size, some being three times as large as the others. We never find, however, in an adenoma of the kidney, the typical kidney structure with its glomeruli and tubules. This departure from the type of the mother tissue is also seen in other places. In adenoma of the large intestine, where this form of tumor is frequently met with, in place of the simple crypts of Lieberkühn, we have branched and twisted tubules, with an epithelium identical with the ordinary cylindrical epithelium of the intestinal tract. Fig. 64 shows a secondary nodule in the liver from an adenoma of the rectum. The general type of the glands of Lieberkühn is well shown, though in one place the buds given off and the union of the two tubules show the tendency to a departure from the type. We sometimes find in the liver small circumscribed nodules about as large as a miliary tubercle, which differ markedly from the liver-tissue. The cells composing them are larger than the liver-cells, are paler, finely granular, and wanting in the ordinary bile pigment in cases where from cirrhosis or other cause the liver-cells are strongly pigmented. This latter fact would show that the cells did not serve the same physiological purpose as the liver-cells. The lines separating the cells of the nodule are more sharply marked than in the normal tissue. The typical arrangement of the liver-structure, the framework of cells branching out from the hepatic vein, with capillaries between them, is wanting here. On the contrary, the cells are in some places arranged in masses, in others they seem to be irregularly arranged around a lumen, as in the ordinary tubular gland. This would seem to represent a return of the

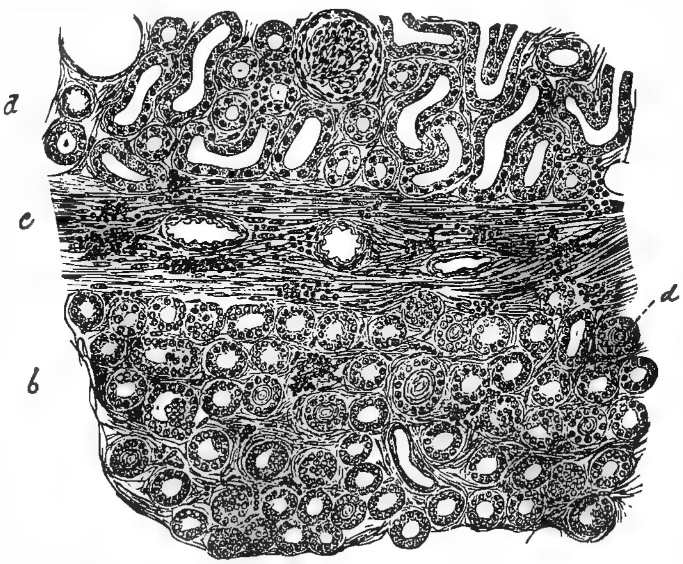

FIG. 63.—Adenoma of the Kidney. *a*, Normal structure of the kidney; *b*, adenoma; *c*, sheath of connective tissue investing the tumor and separating it from the kidney; *d*, colloid masses in the acini of the tumor. (× 70.)

complicated liver structure of the higher vertebrates to the simple tubular form of gland which is found in some reptiles. Other large adenomata have been described in which a distinctly tubular arrangement was found. Whether such larger tumors represent a further stage of development of these small microscopic nodules is not known. The latter seem to have escaped the attention of writers on this subject, and should be considered as true adenomata.

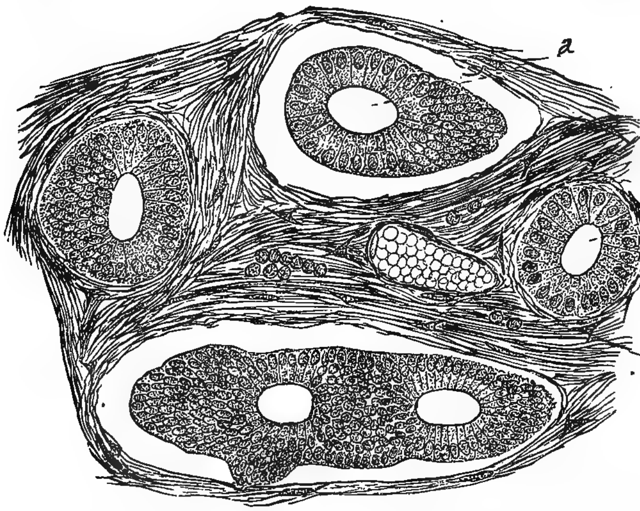

FIG. 64.—Metastasis in the Liver from an Adenoma of the Rectum. *a*, *a*, Acini of tumor; *b*, blood-vessel. (× 220.)

There is one adenoma which, from the frequency of its appearance, and its importance as concerning the life of the patient, merits a special description. This is the adenoma of the ovary. We owe to the works of Waldeyer and Klebs the recognition of this form of tumor in this organ. It generally appears under the form of multilocular cysts, which contain a thick viscid fluid of about the consistency of starch paste. The contents may be colorless, or have every shade of color up to a dark brown, this color depending, of course, on hæmorrhages which have taken place within the cysts. The larger of these cysts are lined with a single layer of cuboidal or cylindrical epithelium. In other places, where soft medullary masses are found, and where, macroscopically, no cysts are to be seen, we find a different structure. Here, under the microscope, we find small cysts lined by a membrane in which are indentations similar to simple tubular glands; these pouches are lined with cylindrical epithelium. There are long papillary projections of the lining membrane into the cysts, and Wilson Fox supposes that the numerous cysts are formed by the union of these papillæ, either with each other or with the cyst-wall. Klebs, on the other hand, supposes they are formed from dilatation of the small pouch-like glands of the lining membrane. Pflüger has pointed out the glandular structure of the ovary, and Spiegelberg and Langhans have shown in it, even after birth, residues of its embryonic glandular structure, and there is little doubt that the adenoma develops from this tissue. Other adenomata are found here which are composed of cysts lined with distinctly ciliated epithelium. Although frequently in these tumors nothing of the ovary can be found, there is little doubt that they do not develop in this organ, but at a little distance from it, in the parovarium. There are other cysts in the ovary which are formed from simple dilatation of the Graafian follicles; but these, as we have shown, should be excluded from the tumors. (See Art. Tumors.)

All of the forms of adenoma of which we have spoken differ more or less in histological structure from the parent tissue; but there are others which conform in every detail with the tissue in which they arise. The thyroid body is very frequently the seat of adenoma formations; these appear under the form of distinctly circumscribed nodules, separated from the rest of the gland by a sheath of connective tissue. The colloid formation common to the gland is always seen in these adenomata. There is an hypertrophy of the gland caused by a diffuse hyperplasia of all parts of it, which must be separated from the tumors. This appears to depend upon the existence of a distinct miasm, which is found only over a limited geographical area. It can be distinguished from the adenoma by its affecting all parts of the gland, and by its spontaneous recovery when the patient removes from the miasmatic region, or under the use of suitable medication. Here we have a case in which, from a microscopic examination alone, we cannot say whether we have to do with a hyperplasia, a tumor, or normal glandular tissue.

Many tumors of the mamma combined with the formation of cysts have been described under the name of adenoma. In such cases the tumor is generally a fibroma or sarcoma, which has grown into the acini and ducts of the gland in the shape of papillary projections. These, of course, will be covered with lining epithelium, and there must be some growth of the epithelium in consequence; but this is only secondary, and the tumor should be considered as a connective-tissue formation. From some descriptions of circumscribed tumors, in or adjoining the gland, which are almost entirely epithelial in character, we must believe that they are adenomas. Regarding these circumscribed adenomata, Billroth says ("Krankheiten der Brustdrüsen," p. 76) that he has never seen a tumor which, after exact histological analysis, allowed only the interpretation of a pure circumscribed adenoma to be given it. Cornil and Ranvier take almost similar grounds. There are a few cases on record in which the glands at an early age, the time of puberty or a little later, grew suddenly to enormous dimensions. In one case observed by Billroth, in a virgin of fifteen years, the breasts grew to mammoth proportions in two and one-half months; the left measured 23 inches in circumference, and in its largest part

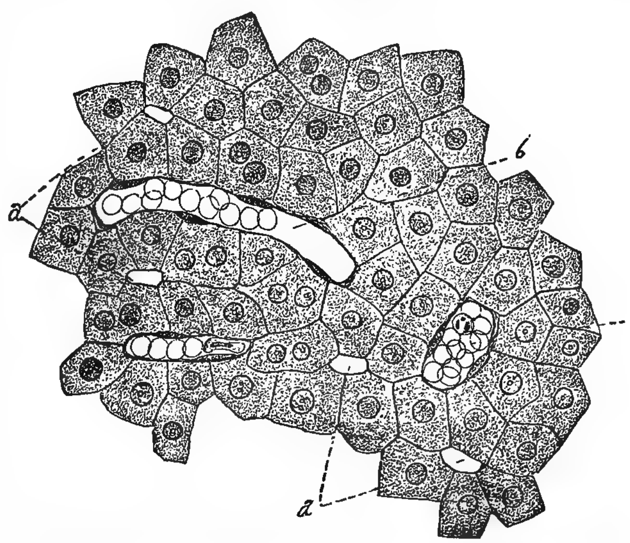

FIG. 65.—Miliary Adenoma of the Liver. At *a* the cells are arranged around a lumen; *b*, *b*, blood-vessels. (× 380.)

was 10½ inches in diameter. There is little known about the histological structure in these cases. The one case investigated by Billroth was complicated by the formation of numerous fibroid tumors in the gland. There was, however, between the tumors an abundant formation of glandular tissue which was similar to that of the normal mamma. Such cases are set down as diffuse adenoma of the breast.

The rapidity of growth of an adenoma differs in the various parts of the body in which it has its seat, and the same holds true for its malignity. There are few which can be strictly considered as benign tumors; there are several cases reported in the literature, of fatal metastases from the adenoma of the thyroid. In the sweat, sebaceous, and lachrymal glands they grow slowly and usually remain local; in the lachrymal gland they may reach a large size, and by the displacement of the eye produce great disfigurement. Some, as the adenoma of the ovary, never produce metastasis, though they may endanger life by their immense size. There are few tumors which are more malignant than the adenomata of the digestive tract. They have all the properties of ma-

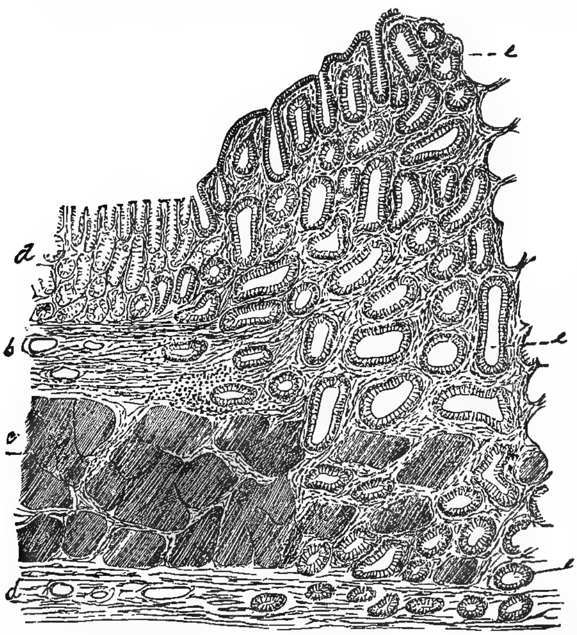

FIG. 66.—Adenoma Destruens of the Stomach. *a*, Mucosa; *b*, submucosa; *c*, muscular coat; *d*, peritoneum; *e*, *e*, *e*, the acini of the tumor. (From Ziegler.) (× 40.)

lignant tumors; they infect surrounding parts and cause metastases. In the intestine the different coats are successively attacked, and perforation often results. Ziegler, in recognition of these destructive properties, has given the name of adenoma destruens to these formations. The figure here given shows such an adenoma of the stomach. As might be expected from the similarity of their respective histological structures, transition forms between the carcinoma and adenoma are frequently seen. The typical glandular structure of the adenoma has only to become atypical and we have the carcinoma. Indeed, the relation between the two has always seemed to me to be similar to that between the fibroma and sarcoma, the former representing the typical connective-tissue tumor, and the latter the atypical. Just as we can have every transition stage between the fibroma and the sarcoma, so we can have the same condition of things between the adenoma and carcinoma; and just as we speak of the fibro-sarcoma in such cases, so we can designate these glandular tumors by the term adeno-carcinoma. Such tumors are frequently seen in the uterus and digestive tract. One part of the tumor will represent the typical arrangement of the adenoma, the alveoli of epithelial cells with a central lumen, and the other part the carcinoma with the solid irregular masses of epithelium growing into the tissue in all directions. All sorts of degenerations are common in the adenoma, and hæmorrhages are frequently met with. In one point they differ most markedly from the hyperplasias, and that is in their never being able, no matter how typical of gland structure their tissue may be, to exercise the physiological function of a gland.

We know very little with regard to their ætiology; perhaps they will bear out Virchow's theory as to irritation less well than any other tumor except the teratoma. For some, as the adenoma of the axilla, where a tissue is found corresponding to that of the mamma, or the substernal tumors in which a tissue similar to that of the thyroid body is found, it is probable that the germinal theory of Cohnheim gives us the true explanation; in the one case the axillary tumor depending on a formative defect in the embryonic development of the mamma, and in the other on portions of the embryonic structure of the thyroid gland being left behind in the ascent of the gland. The writer once saw an adenoma as large as a hen's egg seated alongside the lumbar vertebræ, outside of the peritoneum. The tumor was composed of acini, lined with long cylindrical cells; there were metastases in the liver which showed the same structure. Here it was evident that the tumor was due to an error of formation at a very early stage of embryonic life. It would hardly seem possible that such a tumor could develop from the connective tissue; there could be no irritative influence at work here.

We sometimes find adjoining the various organs, sometimes at a distance from them, small formations which resemble the larger organ in every respect. These are known as supernumerary glands, and are most commonly found in the neighborhood of the spleen, suprarenal capsules, etc. At other times parts belonging to one organ may be enclosed in another, as portions of the pancreas in the mucous membrane of the stomach. Such supernumerary glands have been accused of being the parents of adenomata; but there is no proof of this, though such a nodule of pancreatic tissue enclosed in the mucous membrane of the stomach could easily be mistaken for an adenoma.

William T. Councilman.

ADIPOCERE. [*Adeps*, fat, and *cera*, wax French, *adipocere, gras des cadavres.* German, *Fettwachs, Adipocire.*] As the name suggests, adipocere is a material resembling in its gross appearances fat and wax It is a semi-translucent, white, or slightly yellowish substance of about the consistency of cheese at ordinary temperatures; has a greasy feel, and yields slightly when pressed between the fingers. If a piece be rolled between the fingers for a few minutes it becomes much softer. When rubbed with water it forms a lather. Its composition is that of a soap, being made up of oleic and margaric acids in combination with an alkali. Examined under the microscope it shows, occasionally, very numerous scales having a crystalline form; more commonly nothing but fat-globules are to be seen. If it be melted and again allowed to cool, it is found, often, to have crystallized in round masses made up of needle-shaped crystals, radially arranged; hence like stearin.

Most of the specimens of adipocere with which one is familiar come from the macerating-troughs of anatomical departments and from museum jars which have long contained specimens immersed in dilute alcohol. It thus represents the results of a metamorphosis of dead animal tissues placed under peculiar circumstances.

The only special point of interest in connection with adipocere lies in the fact that it is occasionally found in dead bodies which have been buried a considerable time. In fact, nearly all the structures of the body, except the bones, have been found converted into this material. For centuries its presence had been noted in disinterred corpses, but no opportunity was afforded for studying it on a large scale until 1786, when, upon the removal of

the bodies from one of the cemeteries in Paris, a considerable proportion of those buried in the common grave were found by Foucroy to have been converted, to a greater or less degree, into this peculiar, fatty, wax-like material, and to it he gave the name by which it has since been known.

The conditions favoring its formation in buried corpses are still unknown. Doubtless moisture is always necessary; but why, of six or eight bodies buried in close proximity, and hence presumably under like conditions of soil and moisture, one should undergo almost complete change into adipocere, while the others undergo ordinary putrefaction, as has been observed, is at present inexplicable.

At one time it was thought that adipocere might be of medico-legal importance in helping to determine the length of time a corpse had been buried. Foucroy believed that thirty years was required for its formation. Later, this was reduced to one year; and Caspar mentions finding adipocere in the body of a new-born child, which had lain for three months in a house cesspool. It is therefore impossible to establish an idea, from the presence of adipocere in a corpse, as to the length of time it has been buried.

Artificially, adipocere can readily be produced, either by soaking muscle in dilute nitric acid for two or three days, and then washing it thoroughly in warm water, or by allowing the muscle to soak for months in a trough supplied with running water.

Adipocere is probably closely allied to cholesterine.

W. W. Gannett.

ADIRONDACKS. The Adirondack mountain region has recently come into notice as a health resort for persons suffering from pulmonary phthisis. To summer tourists, especially to those of them who are fond of hunting, fishing, and camp life, this region has long been well known, and it is highly esteemed for the beauty and wildness of its scenery. The Adirondack Mountains lie in the northern portion of the State of New York, west of Lake Champlain; many of the mountain peaks attain an altitude of over four thousand feet, and the highest of them (Mount Marcy) is five thousand three hundred and thirty-seven feet in height. "The mountains rise from an elevated plateau, which extends over this portion of the country for one hundred and fifty miles in latitude and one hundred in longitude, and is itself nearly two thousand feet above the level of the sea" (Appletons' "Handbook of Summer Resorts," second edition). Over two thousand square miles of this elevated tract of country is covered with primitive forest growth, the trees being chiefly of the evergreen variety. For his information concerning the climato-therapeutical characteristics of the Adirondack country the writer is indebted to a valuable communication from the pen of Dr. Alfred L. Loomis, of New York City, entitled, "The Adirondack Region as a Therapeutical Agent in the Treatment of Pulmonary Phthisis," and constituting a paper read by its author before the New York State Medical Society in 1879. In this paper Dr. Loomis describes the climate of the Adirondacks as steadily cold in winter, cool in summer, and having a preponderance of cloudy weather at all seasons. The soil is dry. The annual rainfall is about fifty-five inches. Quoting from Dr. E. L. Trudeau, of Saranac Lake, he specifies certain climatic peculiarities of the region in question as follows: "There is no marked preponderance of clear days at any season; on the contrary, the sky, especially in winter, is constantly overcast. This cool, cloudy weather is a marked feature of this climate. . . . The soil is very light and sandy, with here and there rocks, but little or no clay. . . . Pine, balsam, spruce, and hemlock trees abound, and the air is heavily laden with the resinous odors which they exhale."

Dr. Loomis gives the condensed medical histories of twenty cases of pulmonary phthisis, who, up to the time of presenting his paper, had found an alleviation or cure of their disease by a more or less prolonged sojourn in the Adirondack country. Of these twenty no less than sixteen were cases of "catarrhal phthisis," while two were sufferers from "fibrous phthisis," and two were of the "tubercular" variety. Out of the whole number of twenty patients ten recovered, six were improved in health, two received no benefit, and two died. The ten cases cured were without exception cases of "catarrhal phthisis." Of these Dr. Loomis says: "In all the cases of catarrhal phthisis which have reached recovery, either the pulmonary changes were not extensive or they were of recent origin, and improvement commenced soon after reaching the Adirondacks." Of the six improved cases four were cases of "catarrhal," and two were cases of "fibrous" phthisis. The two patients who died were both affected with "catarrhal phthisis." Dr. Loomis says of these, "Although when they came into this region their lungs were extensively diseased, they were much benefited during their stay, and it seems to me that impatience and imprudence had very much to do with the fatal result." The two unimproved cases were both "tubercular." Dr. Loomis concludes his paper by recommending the Adirondack region as suited to cases of "catarrhal phthisis," while he considers the Colorado climate better for patients presenting the lesions and symptoms of "fibrous phthisis." "Tubercular" cases he considers unlikely to derive much benefit from climate cure. Anything like full and accurate meteorological data for the Adirondack country the writer of this contribution to the HANDBOOK has been hitherto unable to procure. He hopes to be able to present data of this kind for individual health-resorts lying within, or on the borders of, the Adirondacks, in the accounts of such places which will appear in their alphabetical order in later pages and later volumes of the book. For description of the Home for Consumptives, established by Dr. E. L. Trudeau at Saranac Lake, see article on Saranac Lake.

Huntington Richards.

AËROTHERAPEUTICS. Aërotherapeutics, or pneumato-therapeutics, treats of the use of atmospheric air as a curative means by *artificial* changes of its density, as opposed to climatology. This air of increased or diminished density may be applied to the whole or part of the body; the former by means of a pneumatic chamber, the latter by special apparatus, according as it is desired to affect the air-passages, limbs, or other part.

The pneumatic chamber is an apartment usually made of iron, so built that it may be closed air-tight, and capable of standing great pressure external or internal, and large enough for the comfort of the patient. By forcing air in or sucking it out by means of an air-pump, after the patient is in the chamber, the air is increased or diminished in density, the amount of change of pressure being shown by a manometer. There may also be arrangements for regulating the temperature and dryness of the air in the chamber. In using the compressed air-chamber the pressure of the air and the duration of the exposure are gradually increased, possibly to two atmospheres. The time of each bath may be from one and a-half to two hours; the patient going in at the ordinary pressure, this is gradually increased and as gradually diminished. If the pressure be changed too suddenly, the following symptoms may be induced: redness of face, hard, frequent pulse, dyspnœa, cough, hæmorrhages from ear, mouth, nose, or bronchi, spinal troubles, etc. These symptoms are due to the mechanical effect; but there is also increased supply of oxygen. When in an air-chamber, as a diving-bell, the pressure is increased, there comes a feeling of fulness in the ears from difference in density of the air in the ears (*i.e.*, in the drum cavities) and outside of them; unless this difference of density be equalized by passing air through the Eustachian tubes by swallowing, the feeling in the ears becomes very painful, and there may be rupture of the drum-membranes with hæmorrhage. This motion of swallowing must be repeated occasionally till the maximum density is reached, and again as it is being reduced in density. But the most important effects are on respiration, and these are the usual cause of employment of the remedy. Compressed air increases the vital capacity of the lungs, reduces the frequency of inspira-

tion; consumption of oxygen is increased, and excretion of carbonic acid diminished; change of tissue is promoted; the strength, weight, and appetite are increased; there is no special change in the bodily temperature. Under the continued use of compressed air this improvement in symptoms may become permanent. The parts most directly exposed to this compressed air are the surface of the body and the lungs; hence the blood would be driven from the surface and the lungs dilated. After the change of pressure has continued some time, this difference ceases. As the pressure is reduced, the first effect is again on the surface and lungs; the skin and external mucous membranes are filled with blood; the lungs are retracted, until the state of equilibrium is reached. According to this, we might hope from treatment in the compressed air-chamber to drive blood from the periphery, to arrest secretion from the bronchial mucous membranes, by enriching the blood and tissues with oxygen to improve nutrition, to cause absorption of exudations, and to increase excretion of urea, and by expanding the lungs to increase their vital capacity. The action of the compressed air-chamber in lung diseases may be to some extent replaced by portable apparatus for respiration.

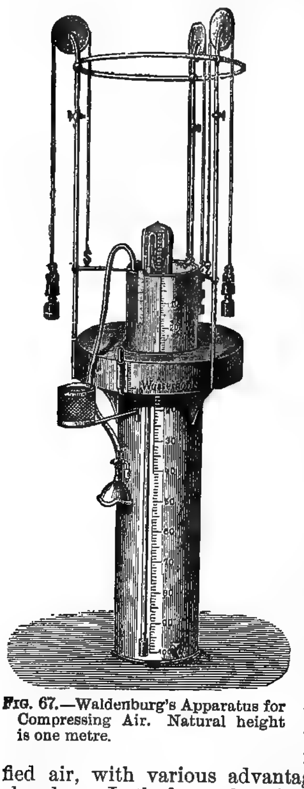

FIG. 67.—Waldenburg's Apparatus for Compressing Air. Natural height is one metre.

The diseases in which benefit may be hoped for by using increased air-pressure are chronic bronchial catarrh, with increased secretion; chronic vesicular pulmonary emphysema, especially if due to bronchitis or asthma; pulmonary phthisis. In this latter disease, as well as in pleuritic exudations and whooping cough, it is said the symptoms are relieved and actual improvement brought about. Advantage has also been claimed for its use in anæmia and obesity. It is said to be contra-indicated in organic diseases of the heart.

The compressed air-chamber may be so arranged (by letting a tube through one of the walls) that while the patient is in it he may expire into the free air; this has the same effect as if, being in the free air, he expired into rarefied air. The air-chamber may also be used for treating patients by rarefied air; but mountainous regions furnish about the same rarefied air, with various advantages over the pneumatic chamber. In the latter there is diminished supply of oxygen; at first the breathing is superficial and frequent, but after a time the inspirations become deeper; expiration is facilitated; the surface colors up; there may be dizziness and mental hebetude. Waldenburg found increased fulness of the radial artery, increased rapidity of circulation, and relief to the heart's work.

Health resorts, which are frequented on account of their elevation, are usually from 550 to 1,900 metres (about 1,800 to 6,200 feet) above the level of the sea, and this diminution of atmospheric pressure would represent about one-fifteenth to one-fifth of an atmosphere. The effect of these is stated in the article on Climatology.

Portable pneumatic apparatuses are arranged for permitting inspiration of, or expiration into, compressed or rarefied air; of these the only methods used are inspiration of compressed air, or inspiration into rarefied air. Pneumatic treatment of diseases of the lungs and heart by these portable apparatuses is of recent introduction; they offer the air under a positive or negative pressure (compressed or rarefied) of $\frac{1}{130}$ to $\frac{1}{20}$ of an atmosphere + or −.

There are many different patterns, of which perhaps the most practical are Waldenburg's and Biedert's; the former is made like a gasometer, the latter much like a round accordeon, with one end fast to a stand having guide rods at the side, with an axle in the middle on which the instrument may be rotated so as to bring the end which is fast uppermost; in this position the patient may breathe into rarefied air, the rarefaction being increased by addition of weights to the lower, free end; when the attached end is down, more weight on top increases the density of the air in the reservoir, so the patient may inspire condensed air. Another instrument, Fränkel's, is made on the harmonicon principle, the patient condensing or rarefying the air by compressing or opening the instrument. All of these instruments have tubes connecting with them, and have mouthpieces and masks at the other ends for the patients to breathe through, and some of them have means for warming or medicating the air entering the reservoir.

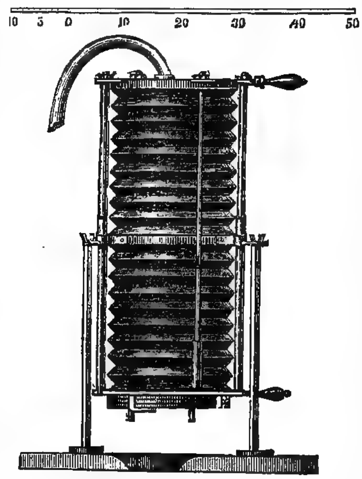

FIG. 68.—Biedert's Apparatus.

Inspiration of compressed air fills the lungs to an unusual degree, expands the chest, and even causes a feeling of distention and fulness; it multiplies inspiratory movements, increases the exchange of gases and the capacity of the lungs, relieves dyspnœa and promotes expectoration.

Expiring into rarefied air has effects somewhat similar to those of breathing condensed air; more air is drawn out of the lungs by this process than can be forced out by the muscles. It is asserted, that, with a vital capacity of 3,000 to 4,000 c.c., by expiring into air rarefied by one-sixtieth to one-fortieth of an atmosphere, 500 to 1,000 c.c. more may be drawn out; this would leave so much more air to be breathed in; and ventilation in the lungs would be increased to this extent, the respiration would become more active than from inspiring compressed air, and the respiratory muscles would be strengthened.

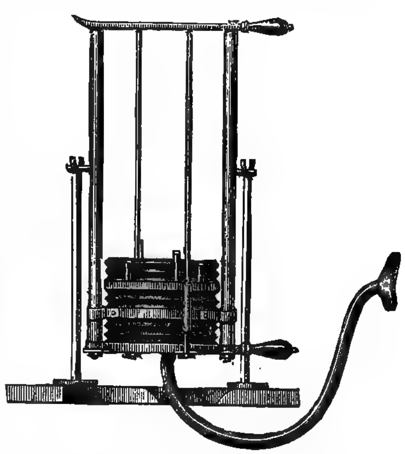

FIG. 69.—The Same, reversed.

Prof. Bazile Feris, considering dyspnœa in emphysema

to be due to lack of elasticity of the alveolar walls, has devised an "elastic respirator" to facilitate expiration. "It resembles a double hernia truss; from a pad between the shoulders the two limbs of the truss pass around under the arms to the terminal pads in front." The effect of pressure at the upper anterior part of the chest is to increase expiration, inspiration then following easily. In thirteen cases the immediate relief is said to have been marked. In the very aged, with rigid ribs, or when the emphysema is accompanied by bronchitis, the relief is less marked.

Inspiration of rarefied air would be merely for gymnastic purposes, to increase the strength of the respiratory muscles; the same would be true of expiring into compressed air. Inspiration of compressed air increases the pressure of blood in the aortic circulation, and reduces it in the pulmonary. As a consequence, we have its diuretic effect and its aid in removing pleuritic exudations. The deep inspirations, with the consequent movements of the diaphragm and stomach, improve digestion and the general condition of the patient. In cases of lung disease, it is sometimes advised to have the patient lie on the healthy side, or to apply adhesive plaster to the healthy side, or, in disease of the apices, to compress the lower part of the thorax by a bandage, so as to throw more work on the affected part. Another method is to place the hand of the sound side on the hip, the other hand on the head while breathing. Climbing mountains is good gymnastics for those patients able to indulge in such exercise. Inspiration of compressed air is indicated where the breathing is weak, where the lungs do not expand well and contain too much blood, to hasten absorption of fluid exudations, in disease leading to phthisis, chronic bronchial catarrhs, etc. In most of these diseases it is well to begin with air but slightly increased in density, and to increase the density up to one-sixtieth or one-twentieth of an atmosphere additional. Medicinal vapors of creasote, turpentine, tar, muriate of ammonia, etc., may be added to the air. The inhalations at one sitting may amount to one hundred, and may be given twice daily. In dyspnœa from asthma, pneumonia, pressure of pleuritic or ascitic fluid, poisoning by gases, etc., compressed air has afforded great relief (just as oxygen has), but, in pulmonary emphysema, expiration into rarefied air has a better effect; it should be used in the same manner. Especial benefit has been claimed from its use in cases of pleuritic effusions and in deformities of the thorax from compression of a lung after pleurisy. In addition to the above cases, in which the pneumatic apparatus may be said to have served as a curative remedy, it is sometimes resorted to for temporary relief in contraction of the larynx or trachea from croup, syphilis, goitre, etc.

Contra-indications to the use of such apparatus are tendency to hæmorrhages from the lungs, stomach, and kidneys, hæmorrhoids, or profuse menstruation, and existence of atheromatous arteries, in which latter condition cerebral hæmorrhage may be induced.

Other therapeutic applications of compressed and rarefied air are made by means of various apparatus prepared to be applied over different parts of the body; a metal casing may be made for part of or the entire thorax (especially of children), fitted close at its edges by means of india-rubber and adhesive plasters, so that air may be pumped out of it; the pressure of ordinary air entering the lungs would then expand them more thoroughly. In chronic inflammations and exudations about the joints a metal casing may be applied over the limbs, and alternations of pressure applied in the same way. The old appliance thus constructed, called Junod's boot, was greatly vaunted in its day.

In the *Bull. gén. de Thérap.*, September, 1883, Dr. Maurice Dupont has an article on "Douches of Compressed Air." He employs air under a pressure of three atmospheres, conveying it by an elastic tube with a nozzle having an opening of eight to ten millimetres. The jet of compressed air is played on the patient as water might be; what he terms the "flagellation" drives the blood from the surface, making it cold; this is soon followed by reaction, without friction being required, as when water is used. After the douche the patient feels warm. This mode of treatment is recommended for phthisis, chlorosis, anæmia, and obesity; and for certain local troubles of joints, contractures, etc.

Compression of air in the lungs, by closing the mouth and nose while making forced efforts at expiration (Valsalva's method) may be tried when a pneumatic apparatus is not at hand; the effect is something like breathing into compressed air. The reverse, viz., trying to inspire while mouth and nose are closed, would be like breathing rarefied air, and has been advised in diseases of the right heart. Deep, slow inspirations increase the flow of blood to and expand the lungs, and increase the aëration and muscular tone of the thorax; hence they are useful in phthisis. Expirations may be made more effective by pressure on the thorax walls by the hands; this forces out some of the residual air, and with it mucus which may have clogged the smaller bronchi. This forced expiration may be repeated twenty or thirty times at one sitting.

Charles E. Hackley.

ÆSTHESIOMETER. The word æsthesiometer is derived from the Greek *αἰσθάνομαι*, I perceive, *αἴσθησις*, perception, sensation, and *μέτρον*, a measure; thus meaning literally a measure of sensation, and is used to denote an instrument, which measures that form of sensation known as tactile sensibility (*Tastsinn* in German).

Tactile sensibility comprises all those forms of sensation which are conveyed to the central organs by the so-called tactile fibres or nerves of touch, and is to be distinguished from the common sensibility, which comprises the sensations conveyed by the sensitive nerves proper. Through these latter nerves we are enabled to feel the *general* or *common sensations*, which include pain, itching, titillation, sensual pleasure, and the sensation resulting from electrical stimulation. On the other hand, through the tactile fibres we obtain the sensations of tactile impression, which are composed of the sensations of locality or position (*Raumsinn*, *Ortsinn*, in German), of pressure and of temperature. Not only is it probable that these different classes of afferent nerves possess different terminations and end organs, but they have, in all probability, each special afferent fibres of their own, which take different courses in the spinal cord.

Æsthesiometers, properly so-called, are instruments for testing the sense of locality. The first one used, one which under slight modifications still retains its place, is that of E. H. Weber, who in 1829, appears to have published his first account of his investigations in regard to the sense of locality. The instrument had probably, however, been for some time in use at that date, for in 1846 he refers to its use twenty years ago. It consisted simply of a pair of compasses with cylindrical arms, the points of which were so ground down that their ends had a diameter of one-third line, so that they should produce simply a sensation of touch and should avoid any sensation of pain. To use this instrument it was only necessary to place the two points upon the skin of the person to be examined, taking care at the same time that he should not see whether both points or only one touched his skin, and by examination find out at what distance from each other it was necessary that the points should be in order that they should be distinctly felt as separate. For in any portion of the skin two distinct points if placed near enough together will be felt as only one.

Weber found that the sense of locality, that is, the distance at which the points could be distinguished as two, varied much in healthy individuals in different parts of the body, and varied also somewhat, especially on the limbs, according to the direction in which the points were placed, whether longitudinally, obliquely, or transversely. His figures and those of Valentin for the normal distance between two points, which can be distinguished as such in the various parts of the body, are as follows;

Table of Variations of the Sense of Locality in Different Portions of the Skin (Weber and Valentin).

[The subjoined table gives the mean minimum distances (in Paris lines) for different parts of the body between the points of the æsthesiometer at which two impressions can be distinguished when the points are applied simultaneously. The first column gives the results of the experiments of Weber, the second of those of Valentin, while the third column (also from Valentin) gives the relative obtuseness of each portion of the body, the most delicate part, the tip of the tongue, being taken as the unit of measurement.]

Part of Surface.	Weber.	Valentin.	
		Mean.	Relative obtuseness.
Tip of tongue	0.50	0.483	1.000
Palmar surface, third phalanx of forefinger	1.00	0.603	1.248
Palmar surface, third phalanx of middle finger	1.00	0.706	1.462
Palmar surface, third phalanx of ring-finger	1.00	0.723	1.497
Palmar surface, third phalanx of thumb	1.00	0.725	1.501
Palmar surface, third phalanx of little finger	1.00	0.733	1.518
Red surface of under lip	2.00	1.500	3.106
Red surface of upper lip	2.00	1.520	3.147
Palmar surface, second phalanges of fingers	2.00	1.558	3.226
Palmar surface, first phalanges of fingers	..	1.650	3.416
Dorsum of tongue (one inch from tip, Weber)	4.00	1.916	3.967
Dorsal surface, third phalanges of fingers	3.00	2.125	4.400
Portion of lips not red	4.00	2.208	4.572
Tip of nose	3.00	2.250	4.658
Edge of tongue, one inch from tip.	..	2.478	5.130
Palmar surface of the metacarpus (capitula ossium)	3.00	2.625	5.434
Lateral surface of dorsum of tongue		2.500	5.176
End of great toe (plantar side of last joint, Weber)	5.00	3.250	6.729
Metacarpal joint of thumb	4.00	3.333	6.901
External surface of eyelids	5.00	3.833	7.936
Palm of hand	5.00	3.833	7.936
Dorsal surface of second phalanx of thumb.	5.00	3.893	8.060
Dorsal surface of second phalanx of forefinger	5.00	3.893	8.060
Dorsal surface of second phalanx of middle finger	5.00	3.900	8.075
Dorsal surface of second phalanx of little finger	5.00	3.943	8.163
Dorsal surface of second phalanx of ring finger	5.00	3.971	8.221
Centre of hard palate	6.00	4.042	8.369
Mucous membrane of lips near gums	9.00	4.125	8.540
Skin of cheek over buccinator	5.00	4.541	9.402
Skin of cheek over anterior part of malar bone	7.00	4.620	9.565
Dorsal surface, first phalanges fingers	7.00	4.917	10.180
Prepuce	..	5.100	10.559
Dorsal surface of heads of metacarpal bones.	8.00	5.250	10.869
Cheek, over posterior part of malar bone	10.00	5.286	10.944
Plantar surface of first metatarsal	7.00	5.875	12.164
Lower part of forehead	10.00	6.000	12.422
Back of hand	14.00	6.966	14.423
Lower part of hairy scalp in occipital region	12.00	8.292	17.168
Surface of throat beneath lower jaw	15.00	8.292	17.168
Back of heel	10.00	9.000	18.634
Pubes	...	9.200	19.048
Crown of head	15.00	9.583	19.840
Patella and surrounding parts	16.00	10.208	21.135
Areola around nipple	...	12.066	24.982
Dorsum of foot, near toes	18.00	12.525	25.932
Axilla	...	13.000	26.915
Skin of forearm (upper and lower extremities of forearm, Weber)	18.00	13.292	27.520
Back of neck (over spinal column, Weber)	24.00	13.292	27.520
Upper and lower extremities of lower leg	18.00	13.708	28.381
Penis	18.00	13.850	28.675
Acromion and upper part of arm	18.00	13.886	28.708
Sacral region	18.00	14.958	30.969
Sternum	20.00	15.875	32.867
Gluteal region	18.00	16.625	34.420
Middle of arm	30.00	17.083	35.368
Middle of thigh	30.00	17.633	36.507
Spine near middle of cervical vertebræ	30.00	18.542	38.389
Spine near fifth dorsal vertebra	24.00	19.000	39.337
Lower part of thorax, and over lumbar vertebræ	24.00	19.912	41.225
Middle of dorsal vertebræ	30.00	24.208	50.120

Weber's æsthesiometer is still in constant use, and serves its purpose well, but certain other forms or modifications have been introduced. In 1858 Sieveking published the account of his æsthesiometer in the *British and Foreign Medico-Chirurgical Review.* The principle is the same as that of Weber's, but the form is somewhat altered. Instead of using the common compasses Sieveking has made his instrument in the form of the beam-compass used by mechanics; that is to say, of a solid graduated bar of metal, which terminates at one end in a point running at right angles to the bar, while on the bar slides another point of horn or ivory, which can be fixed at any desired distance from the first, by means of a screw on top. A modification of Sieveking's æsthesiometer has been made by Brown-Séquard, who has apparently made both the bar itself and the points lighter, and has done away with the screw at the top of the movable point. In his instrument the points are of steel, and there is a roughened prominence on the side of the second point to enable it to be readily moved by the finger or thumb (see Fig. 70). Nearly all the æsthesiometers

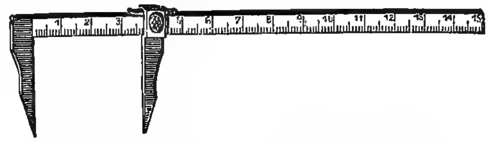

Fig. 70.—Brown-Séquard's Æsthesiometer (reduced in size).

at present used are modifications of these two forms. Hammond's convenient little instrument is a modification of Weber's, consisting essentially in allowing the index-bar to swing on a rivet fastened to one arm of the compass, the bar, while in use, being held by a catch on the other arm, in which it slides freely. When not in use, it can be lifted from the catch and swings into approximation with the arm to which it is fastened, so that the whole instrument, when closed, occupies but little space and can readily be carried in the pocket. Carroll's instrument is simply a compass, each arm of which ends in two points, one blunt and one sharp, either of which can be used as desired; while Vance's is an arrangement of compass with flattened arms, which shuts up in a case like a penknife.

The delicacy of the sensation of space in various parts of the skin may be tested by the æsthesiometer in two ways. In the first place, as mentioned above, by determining how far apart the points must be placed in order to be felt distinctly as two separate points in any part of the skin; and, secondly, by fixing the points of the æsthesiometer at a certain distance apart and moving the instrument from one portion of the body to another. Thus it is found that the distance of the two points appears to increase when the æsthesiometer is drawn from the cheek horizontally over the mouth, one point resting on each lip, to the median line, and that if continued across that line to the other cheek, the distance appears proportionately to diminish. This method of testing with the æsthesiometer is, however, of no practical use, as we have no means of measuring the strength of our sensations.

From the numerous experiments made in regard to the normal tactile sensibility the following results have been deduced: 1. The points of the æsthesiometer always seem to be farther apart when one point is placed on one side of a natural opening and one on the other. Thus, when one point is placed on the upper lip and one on the lower, they appear farther separated than if both points are placed in a corresponding position on either lip. This in part accounts for the increase apparent when the æsthesiometer is moved from the cheek to the median line in Weber's experiment. 2. Other things being equal the points of the æsthesiometer seem farther apart when they rest upon different tissues. Thus, for example, when one point is placed upon the mucous membrane of the lip and one point upon the skin, they seem farther apart than when both points are upon either the skin or the mucous membrane. 3. As a rule the points seem farther apart when they are on different sides of the median line than they do in corresponding positions when both are on the same side. This law does not, however, always hold good. 4. The direction in which the points are placed in relation to each other is of considerable importance in certain parts of the body, especially on the limbs. When placed transversely they appear to be at a greater distance from each other than when placed longitudinally. On the body proper there seems to be but little difference, while it is more marked on the face, and more so still on the limbs, especially the lower arms and legs. The cause

of this is as yet unknown, but it may be that the skin over different muscles responds more readily to two stimulations than the skin over the same muscle when touched at two equally distant points. (According to Vierordt the relative delicacy of the sense of locality at any point on the skin of a special portion of the body, as compared to that of the other points of the same portion, is a function of its mobility, and increases proportionately to its distance from the axis on which that part moves, since it depends on the relative greatness of the excursions which it effects about its axis through the movements of the part concerned.)

In applying the æsthesiometer certain precautions should always be observed. In the first place, the operator should take especial care that both points are applied as nearly as possible *simultaneously*, as the element of time enters distinctly into our tactile impressions, and the greater the time which elapses between any two impressions of a similar kind, the more readily are such impressions recognized as distinct. For this reason, also, the points, when once applied, should not be moved, for if they be moved, a new sensation, or a series of sensations, will be produced, which will enable us to interpret the impressions more easily. It is a curious fact that, if two points be placed so near together that they are felt as only one, and a third point be drawn across the skin between the two, the sensation of a moving object can be felt, although its position cannot be localized. The impression produced by the points, moreover, becomes clearer the longer they remain in contact with the skin. Hence, in making comparative observations, the points should be held on each place for the same amount of time. In addition to the simultaneousness of the touch, the pressure at the two points should be as nearly equal as possible. As far as possible, *all* pressure should be avoided, and when this cannot be, it should be as slight as possible. As we shall hereafter see, the ratio of the sense of pressure in different parts of the body varies considerably from that of locality, and the two different sensations should be carefully distinguished. For practical purposes, however, the amount of pressure exercised in ordinary cases when due care is taken is not sufficient to in any way affect the result. It is otherwise, however, when a different amount of pressure is exerted on the two points. The force of the stimulus produced at one point is liable so to act that the stimulus produced at the other is perceived but indistinctly or not at all. A third and obvious precaution to be observed in using the æsthesiometer, when testing corresponding portions of the body, is that the points should in each case be placed in the same direction, that is, longitudinally, obliquely, or transversely, as may be, and that they should be on exactly corresponding parts and at an equal distance from the median line. This is of especial importance in pathological cases, where the æsthesiometer is used for the purpose of diagnosis.

In an examination for physiological purposes we must also take into consideration the mental condition of the subject. Whenever the attention is strongly fixed upon any point in the body, sensations produced there by external objects are more readily and more quickly perceived than when the mind is occupied by other thoughts. Hence, when the attention is fixed upon the action of the æsthesiometer, the points will be perceived more readily and more distinctly than would otherwise be the case. The readiness with which the points are perceived and their position determined varies also greatly with practice. Cold diminishes the tactile sensibility, as does also extreme heat. Hyperæmia, as well as anæmia, probably likewise diminishes it.

Baræsthesiometer.

The term baræsthesiometer, from βάρος, weight, and æsthesiometer, has been applied to instruments which are used to determine the delicacy of the cutaneous sense of pressure.

The first attempts to measure the cutaneous sense of pressure were made by E. H. Weber, who for this purpose used weights laid directly upon the parts to be tested, the muscular sense being excluded by firmly supporting the part to be examined upon some solid body. Various weights, as nearly as possible of the same size and same temperature, were applied in succession to the part, and the smallest difference which could be thus detected was carefully determined for each part. Weber himself made use for this purpose of coins (thalers) which he laid upon the forehead, the head being supported, and thus obtained some important results. According to his researches, the sense of pressure varies much less in the different parts of the body than the sense of locality, and does not vary in the same proportion in the different parts. In the place of coins Kammler and Aubert made use of small disks of cork or elder-pith, on which weights could be placed, while Dohrn estimated the sense of pressure by means of a blunt point attached to the arm of a pair of scales. In 1863 Goltz published the account of his apparatus, by means of which he sought to determine the smallest *rhythmical* pressure which can be perceived on any given part. For this purpose he made use of an India-rubber tube, both ends of which were closed and which was rendered tense by being filled with water. The pulsations produced by the experimenter at one end of the tube were transmitted to the other end, which was laid upon the part to be tested. Goltz's results corresponded with those of Weber for the *sense of locality*, except that the tip of the tongue was found to be proportionately much less sensitive to pressure.

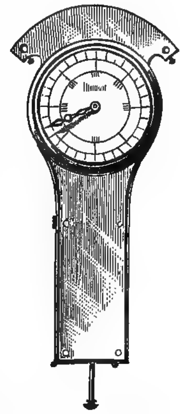

FIG. 71.—Eulenburg's Baræsthesiometer. Front view.

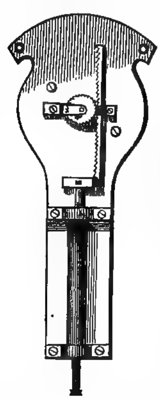

FIG. 72.—Back view of the same instrument.

To determine the delicacy of the sense of *variation of pressure*, Eulenburg used the baræsthesiometer which bears his name (Fig. 71). It consists simply of a hard-rubber plate, on to which is screwed a spiral spring through whose greater or less tension a stronger or weaker pressure can be exerted on the plate. This spring is placed inside a case, and can be more or less compressed at will by means of a guiding-rod. Through a toothed wheel, which is placed in connection with this rod, an index is set in motion, which marks on a dial-plate the amount of tension of the spring, thus showing the strength of the pressure exerted. Each figure on the dial corresponds to a pressure of one gramme. Eulenburg found that the sensibility to variations of pressure was most delicate on the face, especially the forehead, then on the lips, the back of the tongue, cheeks and temples. Here it is $\frac{1}{30}$, often $\frac{1}{40}$. On the upper extremities it is $\frac{1}{20}$ to $\frac{1}{10}$, and does not vary much in the different parts. In the lower extremities the anterior portions of the lower leg and thigh seem to possess the greatest insensibility; next follow the back of the foot and dorsal surface of the toes, while on the plantar surface of the toes, the sole of the foot, and the posterior portions of the lower leg and thigh the sensibility is much weaker. Löwitt and Biedermann found that by the finger-tips the differences between weights which bear to each other the proportion of 29 to 30, could be appreciated, provided the weights were not too light nor too heavy.

Thermæsthesiometer.

For measuring the sensibility to differences of temperature, Weber used two long glass phials filled with oil, into each of which he introduced a thermometer, passing it through the stopper. By means of this ap-

paratus he found that the skin of the face was the most sensitive, especially that of the eyelids and cheeks. The lips, on the contrary, which are more sensitive to sensations of place, are less so to those of temperature. Moreover, the sense of temperature, as tested in this way, instead of being greatest in the middle of the lips, is greater on the lateral portions of the upper lip, greatest on the cheeks, and less as we approach the median line. In 1866, Eulenburg described his thermæsthesiometer. The instrument consisted simply of a "frame" and two thermometers thereto attached. For "frame" he made use of Sieveking's æsthesiometer, to the bar of which he fastened two exactly similar thermometers which corresponded accurately to each other. Their lower ends were drawn into broad glass bulbs, and flattened at the bottom so as to rest readily upon the skin. These thermometers worked like the points of the æsthesiometer, one of them being fixed at the end of the bar, while the other could be moved along it as desired, and be fastened at any distance by means of a screw. Thus the distance between the thermometers was determinable at will, and could be estimated by a scale marked on the bar. In using this apparatus, one thermometer was heated or cooled as desired, while the other was left at the temperature of the room. In the following year, 1867, Nothnagel published a series of very careful investigations into the cutaneous sensibility of the temperature, in making which he used a special instrument. Nothnagel's thermæsthesiometer consists of two exactly similar cylindrical vessels, two and a half inches high and one and a half inch in diameter. Their walls are made of wood and are double, some poorly conducting substance, as ashes, being placed between the two parts. The bottom is formed of copper, a good heat-conductor. On the top of the vessel is a tightly closing wooden cover which moves on a hinge, and which has an opening on one side. Corresponding to this opening there rises perpendicularly from the edge of the vessel a piece of wood to which are fastened two rings. Through these rings and through the opening in the cover a thermometer is thrust into each vessel, which is partially filled with water, whose temperature may readily be rendered different in the two vessels by plunging into it some good conductor, which has been previously heated or cooled. The vessels should be placed rapidly one after the other on the part to be examined, and the time of contact lasts until the subject has formed a judgment in regard to the temperature. Care must be taken that the whole surface of the bottom of both vessels should rest against the skin, since, as is well known, the strength of the impression and the delicacy of the sensibility to temperature grows with the increase in the number of nerve-fibres affected. By this means Nothnagel determined that the greatest capacity for distinguishing differences of temperature exists when the temperature is between 27° and 33° C.; up to 39° C. it is but slightly diminished, but from thence to 49° C. it diminishes rapidly, and at the latter point pain occurs. From 27° to 14° C. the capacity diminishes in much the same ratio as from 33° to 39° C., but between 14° and 7° C. it falls off rapidly. He found that in different parts of the body the following differences in temperature could be distinguished:

	Centigrade.
Sternum	0.6°
Chest, upper and outer portion	0.4°
Epigastrium	0.5°
Abdomen, upper lateral portion	0.4°
Middle part of back	1.2°
Lateral portions of back	0.9°
Palm of the hand	0.5°-0.4°
Back of hand	0.3°
Fore-arm—extensors	0.2°
Fore-arm—flexors	0.2°
Upper-arm—extensors and flexors	0.2°
Dorsal surface of foot	0.5°–0.4°
Lower leg—extensors	0.7°
Lower leg—flexors (calf)	0.6°
Thigh extensors and flexors	0 5°
Cheeks	0.4°–0.2°
Temples	0.4°–0.3°

The sensibility to variations of temperature seems duller as we approach the median line. The hand and fingers are generally alike, the lower arm more sensitive than the hand, and the upper arm more so than the lower arm. By extremes of heat or cold a thermanæsthesia is produced. Anæmia increases sensibility to temperature, hyperæmia is said to diminish it.

The only other thermæsthesiometer which deserves mention is Kronecker's, which resembles Eulenburg's, in which the latter's thermometers are replaced by metal tubes, each divided nearly to the end by a partition, as in a double-irrigating catheter. Through these water of a fixed temperature can be caused to flow.

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William N. Bullard.

AGARIC, PURGING. White agaric (*agaric blanc*, officinal Codex Med.), the decorticated hymenium of *Polyporus officinalis* Fries (*Boletus Laricis* Linn.); order, *Basidiomycetes, Hymenomycetes;* a large fungus growing upon the stems of the European larch and one or two other conifers. It forms large hoof-shaped masses upon the sides of the trunks, and penetrates with its mycelium deep into the wood. When young they are soft and juicy, but, when fully grown, hard, and of a consistence between spongy and corky. The masses are collected in Europe, Asia Minor, etc., and usually prepared by drying and peeling. Agaric is in yellowish-white, friable, light, and spongy irregular balls and lumps, from the size of an orange to that of a cocoanut, and larger. It has evidently been peeled, and the surface is finely rough and dusty with minute separated particles. The texture is rather firm, but soft; it can easily be reduced to a coarsish powder by friction or by rubbing on a sieve, but is difficult to pulverize finely; its microscopic structure—a tissue made up of interlacing, thread-like cells—explains its peculiar consistence.

Agaric has a heavy fungous odor, and a slowly developing, bitter, nauseous taste, which is at first sweetish. Its powder is very irritating to the eyes and nose, and produces violent sneezing. As it is also light and dusty, persons employed in beating it in mortars are obliged to resort to devices to prevent its rising.

It contains nearly one-third of its weight of resinous matters, extractible by strong alcohol, which can be separated further into three or four simple resins by taking advantage of their different degrees of solubility in diluted alcohol, chloroform, etc. (Massing).

Agaric is principally a purgative, owing this quality to one or more of the resins just mentioned. It is also said to be tonic, and to reduce the sweating of phthisis. But although it has undoubtedly purgative powers, it has fallen greatly into disuse, and is only now and then called for, even in Europe, in the United States scarcely ever, as a medicine; it is still in repute in parts of Asia. Can be given in powder. Dose, as a tonic and anti-diaphoretic, fifteen to sixty centigrammes (0.15 to 0.6 Gm., gr. ij. to x.); the last, perhaps, might act upon the bowels. The resin has also been used.

ALLIED PLANTS.—*Polyporus igniarius* Fries (see Spunk) is an allied, although very different-appearing product, used entirely on account of its texture. Composition unimportant. A number of other polypori have been found to be bitter and laxative; some poisonous.

Agaricus campestris Linn. yields an interesting and very poisonous alkaloid, muscarine (see Jaborandi). For a list of fungi used in medicine, see Ergot.

ALLIED DRUGS.—Cathartics: say jalap, scammony, podophyllum, etc. Its relation to tonics, "anti-rheumatics," antisudorifics, etc., are too indefinite for comparison. There are better medicines in each of these groups than agaric.

W. P. Bolles.

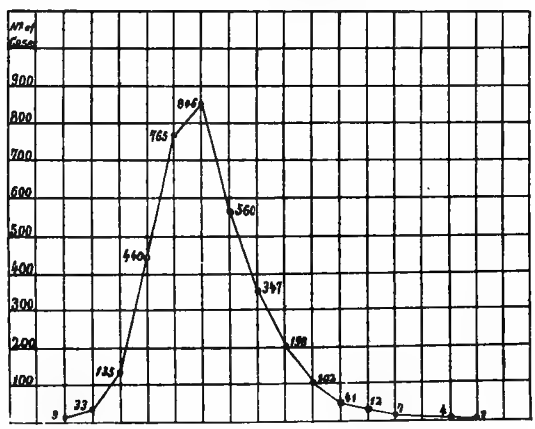
AGE. The age of a human being does not, as usually reckoned, correspond to the length of time it has existed, because the ordinary calculation starts from the date of birth, and excludes the preceding period of uterine existence. If we are to be strictly accurate, the age of any animal ought to be reckoned from the time of impregnation, especially if we are to compare different species, one with another, in regard to the changes which correspond to successive ages. The act of impregnation creates a new individual, which alters as time elapses, and the liberation from the womb is only one of the alterations, one event, occurring in the life-history of the individual; it is therefore artificial to arbitrarily select the date of delivery as the zero point from which to start the reckoning of the age, the more so as we know that the period of gestation varies very considerably in length, and that consequently the age of the child at birth is not by any means uniform. In the case of man it is the most convenient plan to adopt popular custom, because the ages as reckoned from birth are generally known with exactitude, but the age of the fœtus at birth is almost never known for a given individual. Indeed, we have at present no means of determining satisfactorily the age of a human embryo or fœtus, because we have no sufficient available data for ascertaining when impregnation takes place. As is shown in the articles Fœtus and Impregnation, there is always a possible error of several days in any estimate of the age of a fœtus, even when the history of the case is fully and accurately known, and there are decided reasons for thinking that there may be sometimes an error of a month or whole menstrual period. Obviously it is not practicable to calculate the age of man from an event the time of which we cannot know correctly, and it is the only practicable course for us to follow custom, and assume the commencement of life's journey to be some way along the route, namely, at birth; at least, whenever we have occasion to measure age.

From impregnation to death, at the natural term of life, the organism undergoes a definite series of changes, which are termed the phenomena of senescence; in plain words, the organism grows old. The most important, if, indeed, not all the changes, may be grouped under three heads: First, the increase in the number of cells; second, the weight of the cells; and third, the differentiation of the tissues. The first and second are the essential factors of growth, and under Growth they are more fully discussed. Unfortunately, we have no knowledge as to the number of cells in the body at different ages, nor is it possible to make even a valid estimate. It appears entirely practicable for some patient investigator to make an approximate determination of the number of cells in the body; a trustworthy result would be extremely valuable. But though we cannot speak of actual numbers, we are able to say that the rate of multiplication of cells diminishes gradually with one or two possible interruptions in man. The demonstration of this law is given in the article on Growth. As regards the size of the cells, we know that at first the size is reduced; during the segmentation of the ovum, the amount of material remains nearly constant, while the segments (cells) multiply; hence, they necessarily become smaller. During fœtal life they remain small, even after their differentiation into distinct tissues, but it is still uncertain how much of the growth of children is due to the mere increase in size of the histological elements and how much to the increase in their number. The difference between the fœtal and adult cells is readily seen; unfortunately, it is impossible to give a table of comparative measurements, for the micrometric data, even of the best authorities, are, with very rare exceptions, utterly worthless, from their extreme inaccuracy. The structure of the tissues varies according to the age; for each age there is a characteristic phase of development of the histological elements, both in structure and arrangement; hence, the general anatomy and, therefore, also the functions alter in correspondence with the age. Thus, in a philosophical view of the career of any organism, we are compelled to regard it as a function of the time elapsed since the procreation of the individual. It is important to insist upon this conception, because the student of human anatomy derives his notions almost exclusively from the study of the adult, and consequently fails to seize the idea that much of what he conceives to be essential and typical is only temporary.

There is another general consideration to be urged upon the attention of the reader: the older the organism the longer it requires to change. An infant alters more rapidly than a child, an adult more rapidly than an old person. This fact has a more profound significance than at first appears, because it not only suggests the only theory of the origin and nature of natural death having any serious value, but also is the clue to the distribution of variations in age. For the theory of death, see the concluding portion of the article on Growth. The law of variations to which we refer demands brief elucidation. Varieties occur in all degrees; with living organisms there is in each case a certain variety which occurs most frequently, and on either side of this most frequent type (geometrical mean) occur other varieties which are found to be less frequent the more they depart from the central type. On the doctrine of chances the distribution should be alike above and below the mean, provided always there is no predominating factor or factors of variation to disturb the symmetry. In the development of living organisms there is such a disturbance through the effects of age; a concrete example shows the phenomenon plainly. The following table, after Heinricius,[1] gives the ages and number of persons observed in 3,500 recorded cases of first menstruation in Finland. Below the table is given the graphic representation of the same data.

TABLE OF 3,500 CASES OF FIRST MENSTRUATION (observed by HEINRICIUS in Finland).

Ages (years)..	11	12	13	14	15	16	17	18	19	20	21	22	23	25	26
No. of Cases..	9	33	135	440	765	846	560	347	198	102	41	12	7	4	1



Age.. 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 years.

FIG. 73.

The curve shows that the year in which the first menstruation occurs most frequently is the sixteenth, and the further we follow the curve from the maximum, either forward or back, the lower it sinks. Moreover, from the maximum to the minimum is (probably) only seven years on the young side, but ten years on the old side. Here, then, we see that an equal range of variation covers a much shorter period of childhood than of later life. When a larger series of statistics are compiled, the difference in the pre-maximal and the post-maximal periods is found to be considerably greater. This phenomenon occurs not only with menstruation, but with many, and probably all, or nearly all, phases of the development of the body; the time at which a given change takes place varies in different individuals, and, as far as at present known, always according to the law just indicated. In the article on Growth another set of facts are brought forward, demonstrating the same principle, which we may now formulate as follows: *The time required to accomplish*

a change of a given extent increases with the age of the organism.

It is evident that this generalization needs to be tested with great thoroughness, especially to ascertain whether it is rigidly applicable in details, or only in regard to the whole course of development broadly considered. As no researches have heretofore been made to settle the alternative stated, it is very desirable that they should be undertaken. It may be discovered that diseases and recovery from diseases vary in rapidity in accordance with age, the rate of change decreasing with the age. This can be decided only by extensive statistics in regard to organic diseases. A large number of observations of the progress of fatal new formations, of cancer, for example, would be of high value. It is not to be anticipated that the diseases of a parasitic or zymotic character would exhibit, necessarily, any such correlation with age, because their course is dependent primarily on other causes than the condition of the organism in which they appear. If the rate of disease does vary with age, the desirability of knowing the fact is too obvious to require further emphasis; we can, therefore, only express the hope that some one having a proper opportunity will soon make an adequate investigation.

It is a common custom to divide the period of life into a succession of ages, but all such divisions are more or less arbitrary, and though extremely convenient are quite without scientific significance. The ages commonly adopted are: 1, *Infancy*, from birth to the appearance of the temporary teeth; 2, *childhood*, from the cutting of the first permanent teeth to puberty; 3, *youth*, from puberty to the attainment of the full stature, that is, eighteen or nineteen for girls, twenty-one to twenty-two for boys; 4, *maturity*, covers the interval from youth to the climacteric, after which follows 5, the period of decline or *old age*. Another very common distinction is made between the period of development, say up to twenty-five or thirty years, and the period of decline, but, as is explained under Growth, there is a steady decline going on during the first period also. It would, perhaps, be more scientific to designate the earlier phase as the period of histogenesis, during which the tissues are being evolved, and the latter as the period of histolysis, in which the tissues are breaking down—degenerating. But, after all, though a great deal has been written and said, very seriously too, upon the division of life into ages, the discussions have never, and can never, lead to much result beyond fixing upon a set of arbitrary terms, which will always be convenient, provided they are left sufficiently vague.

The other matters which might be put under Age are to be found elsewhere, such as the determination of the age of a skeleton, the age at which the teeth are cut, etc. For the characteristics of infancy and childhood, anatomical and physiological, see the articles on these topics. For the changes in old age, see Senility.

Charles Sedgwick Minot.

[1] Centralblatt für Gynäkologie, 1883, vii., 72 to 73.

AGORAPHOBIA (ἀγορὰ, a market-place, φόβος, fear). [Ger., *Platzschwindel, Platzangst, Platzfurcht;* Fr., *peur des espaces, peur du vide;* It., *agorafobia;* Dan., *agoraphobi;* Rus., *Mestoboyazin.*] Etymologically speaking, these names signify "fear of spaces," and are used to describe a peculiar emotional neurosis characterized by morbid fear of being alone in an open space, or under analogous circumstances. The name agoraphobia not having satisfied every one, its philological accuracy has been questioned, and such terms as *isolophobia, eisophobia,* or *autophobia,* and *kenophobia* have been proposed. However appropriate these designations may be, the term agoraphobia is adopted in the current medical literature of all nations; it is clear, concise, and elegant; it has, moreover, a certain element of fitness and admissibility, since *ochlophobia* is a prominent symptom of the complaint, and one of the latest contributions to the subject is a paper in Greek that is to be found in the "Acts of the Congress of Greek Physicians, held in Athens in 1882." A better notion of the word may be given by detailing some of the salient phenomena that are found in a typical case of agoraphobia. Among the prominent somatic troubles are a sudden weakness and a tremor of the muscles, which render standing difficult. The tremor extends sometimes to the trunk, thence to the arm and to the lower jaw; sometimes there is a wavy sensation going from the heart to the back of the neck. Chilly sensations in the back, stomach, breast, and limbs are followed by heat, redness of the face, profuse sweating, and violent palpitation. At the same time there is oppression and contraction of the pectoral muscles; the speech is abrupt and anxious, and sometimes is momentarily impossible; intermittent pains of a sharp, rapid, and fatiguing character, following the trunk of the nerves, run along the legs, ascend the body, and extending to the arms, seem to lose themselves in the hollows of the hands; there is formication, with numbness in different parts of the body; festination is observed in some cases; in others sudden loss of motor power comes like a stroke of palsy, and the patient falls powerless with his face downward, in a state of waking nightmare.

But these physical troubles are only the outward and visible signs of the moral trouble that is the true primitive phenomenon and the cause of all the others. That which is pathognomonic and constitutes agoraphobia, is *terror*, up to its extreme degree, and consequent motor impotence. The single primitive phenomenon, as the name indicates, is *fear*. Imagine looking down a deep mountain gorge, hanging over the brink of a burning crater, crossing Niagara on a tight-rope, or falling from such a precipitous height as the Washington monument, and the sensation is not more fearful, more astonishing than that felt by a patient in an attack of agoraphobia. Agoraphobic terror causes a patient to feel dumbfounded, thunderstruck, exhausted, and at the same time isolated from the entire world; space seems to extend to infinity under his feet; he feels persuaded that he will never accomplish a given journey; walk a certain distance without fainting; hold out for a certain time without food, or support existence for a certain period without fresh air. He experiences fear and want of self-confidence when in a crowd, at theatre, church, or in a boat, omnibus, or railway car. A case is related of an agrophobe who could not ride on a railway train without a brandy flask in the left hand and a bible in the right, presuming that one counterbalanced the effects of the other. Fear to meet acquaintances; fear of spiders, mice, and snakes; fear of apoplexy and of death come over the patient like the fear that seizes a timid child in the dark; sensations like those of a swimmer deceived by false chances, or those of a victim to tantalizing hopes, cause the patient to be on the point of screaming or weeping, and he is, figuratively speaking, frozen with terror, motionless with fear, so great is the anguish that takes place during this psychical collapse.

Agoraphobic symptoms are not new, Pascal having suffered from them, and Flemming says Brück described them in 1832, and again in 1869, under the title of "Schwindel-Angst." It seems, however, that their systematic observance and study are of recent introduction into science (1871). For convenience of study two forms of agoraphobia are spoken of, namely, primary and secondary. The primitive form may occur suddenly in apparent good health and normal mental conditions, without other morbid symptoms than the usual somatic and psychical ones; the secondary form occurs as an accessory phenomenon complicating a previous pathological condition: it is slow and progressive, and may coexist with other neuropathic conditions. Primitive agoraphobia may come on suddenly without assignable cause amid varying circumstances, in a boat, during a lecture, or while skating, at the sight of an extended horizon, or while looking at the summit of a high monument, as is the case with two of the writer's patients, who cannot look up to the dome of the Capitol or the summit of the Washington monument without being seized with agoraphobic symptoms. In one of the late St. Petersburg cases the patient could not look out on the sea without

agoraphobic symptoms. There was also the "tormenting fear of heights," the rooms on a second story being unbearable, and the patient in crossing a high bridge, always did so in diagonal lines to avoid the sight of the space between him and the water below. Secondary agoraphobia comes on slowly, generally in patients whose neurotic antecedents are bad. Numerous prodromatic symptoms, more or less painful and persistent, are experienced, and at a certain time, while out alone in a public place or highway, or under analogous circumstances, there is added intense emotion and momentary suspension of motor power, which complete the attack. These symptoms often disappear spontaneously, when the sufferer, in crossing a space, can fix his eye on some limited object, such as a carriage, a street lamp, a tree, or an open umbrella held over his head; and often the companionship of a small child, or even the support of a cane will act as a preventive. Among the latest reported cases is that of a Russian officer, who escaped the agoraphobia brought on at the sight of carriages and pedestrians, by always taking an orderly along and keeping on the least frequented streets. He did not have these symptoms outside of St. Petersburg, in a suburban village, nor did they come on when riding horseback through a crowded street at the head of his regiment.

But little is known of the cause or of the precise nature of agoraphobia, and the numerous theories relative thereto are to be mentioned only as objects of medico-historic curiosity. Over-work, prolonged watching, early and excessive sexual indulgences, venereal disease, alcohol and tobacco, excessive use of coffee, gastric disturbances, tænia, rapid decline of corpulency or a rapid change to corpulency, the gouty and the rheumatic diatheses, bad atavistic antecedents, and habitual indulgence in groundless fears, may give rise to its development. In fact, one may become agoraphobic from moral weakness. The atrophy of will that allows imagination full career and gives rise to the superstitious fears, moral miseries, and morbid impressions that assail certain persons, may cause violent commotion of the organism with psychical sensations of terror. By these facts, therefore, it is satisfactorily established that in agoraphobia there is a kind of moral softening, a nervous adynamia, a psychic insufficiency that may dominate the faculties of the individual and sterilize his acts. Whether the condition arise from organic insufficiencies, such as non-activity of the eye or of the ear, brain trouble resulting from anæmia, fatty heart, hæmorrhoids, lesion of the cervix uteri, abscess of the liver, or from a morbid state of the ganglio-nervous apparatus, we are not prepared to say in the present state of our knowledge of the subject. But a consensus of medical opinion warrants the statement that the pathological change in agoraphobia is a cerebral one, giving rise to a cerebro-spinal neurosis that should not be confounded with epilepsy, hypochondria, or the different forms of vertigo. Agoraphobia is said never to occur in hypochondriacs. A patient with hypochondria is constantly under the influence of the disease; it is not so with agoraphobia. It differs also from vertigo caused by looking down from a height. The seeming impossibility to give a purely physical explanation of the disease arises from the fact that it is a purely mental trouble, and it is a curious fact that none of the recorded cases have occurred in ignorant persons. Nor do any of the cases appear to have been accompanied by illusive transformation. Suicidal impulses are, however, reported to have occurred in several cases. The majority of them occurred in adult men of education and intelligence, who, in nearly every instance, kept the symptoms concealed from every one as long as possible for fear of being thought insane.

The administration of drugs in agoraphobia is of less consequence than the removal of the cause, which is to be done mainly by moral treatment. The primitive form often disappears spontaneously, but the healing of the secondary form presents all possible and impossible difficulties, surprises, and uncertainties that the neurologist is accustomed to meet. Among the therapeutic agents recommended are antispasmodics, the bromides, ergot, tonics, and iron; cutaneous revulsives, cups, hydrotherapeutics, electricity to the cervical and to the sympathetic nerves, and electric baths. A case has been bettered after an operation for the removal of hæmorrhoids; in another the agoraphobic symptoms disappeared after aspiration of the liver and draining off a quantity of pus from an abscess. Two cases caused by tænia have been cured after removing the cause. Another case improved after a residence in the country, a course of hydrotherapeutics, and the avoidance of tobacco. In addition to combating the functional and the physical alterations with proper medication, there must be a radical and complete change in the habits and surroundings, which should be as much opposed as possible to the conditions in which the disease has originated; and, above all, the physician should order and enforce a course of moral gymnastics that shall train the patient's imagination, and tame his terror by progressive and regular steps.

Irving C. Rosse.

AGRIMONY (*Agremoine*, Codex Med.; *Agrimonia Eupatoria* Linn.; order, *Rosaceæ*) has been employed in Europe from the time of the ancient Greeks and Romans, by whom it was prized as a vulnerary. It is, however, now almost obsolete, excepting in domestic or country practice. Both herb and root have been used.

It is a perennial plant, with slender, upright, leafy stem, from thirty to sixty centimetres high (one to two feet), bearing a wand-like spike of smallish yellow flowers; leaves impari- and interruptedly-pinnate, with adnate leafy stipules; leaflets lanceolate, sharply serrate; flowers perfect, polypetalous, stamens from five (seldom) to fifteen or more; pistils, two or three, the ovaries buried in the receptacle, which becomes dry and woody in fruit, and is surmounted by a crown of rigid incurved spines.

It is extensively distributed throughout the northern hemisphere, growing along roadside hedges and the borders of cultivated fields in Europe, Asia, and America. The leaves, and especially the flowers, are rather agreeably fragrant; all parts, the root particularly, bitter and astringent. An essential oil has been obtained from the plant by distillation. It is a mild, stimulating astringent, which has proved of some use as a vulnerary, as a gargle, a mild hæmostatic, and an astringent in chronic diarrhœas. More doubtful is its utility in jaundice and other indications of hepatic obstruction, or as so-called alterative. Dose, 4 to 8 grm. (ʒ j. to ʒ ij.), in infusion.

Botanical Connections.—Agrimony resembles the true roses in most details of botanical structure, but differs from them in habit and general appearance, which are more like those of *spiræa ulmaria*. It is also botanically connected with *brayera anthelmintica* (Kouso) Kunth., from which it also differs greatly in habit and the purpose for which the latter is used.

Allied Drugs.—Astringency, bitterness, and aroma, with varying preponderancy of each, form one of the most common medicinal combinations of the vegetable kingdom. Alchemilla, sanguisorba, strawberry, potentillas, geums, blackberries, and spiræas in the same botanical family are instances, and numerous others might easily be mentioned. For remarks on *Rosaceæ*, see Roses.

W. P. Bolles.

AGUE-CAKE. A chronic enlargement of the spleen following repeated attacks of intermittent fever, or accompanying chronic malarial cachexia. (See Malarial Fevers.) To be treated with full doses of quinine and the local application of cold.

E. W. S.

AIKEN. [For detailed explanation of the accompanying chart, and suggestions as to the best method of using it, see Climate.] The village of Aiken lies not far from the western border of the State of Georgia, between the Savannah and Edisto rivers, but at a considerable distance from either, and standing upon the elevated tableland or plateau forming the common watershed of both.

From the Atlantic Ocean, Aiken is distant a little more than a hundred miles in a "bee line." The elevation of the town above sea level is five hundred and sixty-five feet. The soil is very sandy, consisting, indeed, of very little else than such absolutely pure and unmixed sand as is usually to be found only upon the very borders of the sea. Grass grows but scantily, and the vegetation of the surrounding country is that characterizing a region possessing a dry porous soil, and, in consequence, a dry atmosphere. The yellow pine of the South finds here its congenial habitat, and in every direction the country about Aiken is covered with a dense, forest growth of these lofty evergreen trees, shading the ground from the rays of the sun, and filling the atmosphere with the delicious balsamic odor exhaled from their leaves and trunks. Several varieties of oak are also to be found in the woods about Aiken, and not a few flowering vines and shrubs; but the pine is the characteristic growth of the country, and it is to the soothing and purifying effect exerted upon the mucous membrane of the respiratory passages by the exhalations from this tree that the climate of Aiken owes much of its well-deserved reputation as a health resort for persons suffering from all forms of disease affecting the respiratory tract. The other chief factors in producing the healthfulness of this now celebrated resort are the mildness and general equability of its winter climate; the preponderance of bright sunny days, which enable the invalid to pass much of his time in the open air; the protection against the wind afforded by the dense growth of forest trees; and last, but by no means least, the remarkable dryness of the air, already alluded to, and depending upon the peculiar character of the soil and the distance from any large body of water. With the exception of certain stations lying in close proximity to, or west of the Rocky Mountains, no drier air is to be found in the whole United States, and, so far as present observations extend, none so dry as that which exists at Aiken. As might well be expected from what has been stated above, there are no marshes about Aiken, and Doctor W. H. Geddings, a well-known writer on climate and health resorts, and a practising physician resident in the town, makes the following statement in a letter received from him a short time ago: "Malaria is remarkable for its absence. During a practice of fifteen years I have never known a case to originate here." From the dryness and warmth of its climate it may well be inferred that cases of gout and of rheumatism would also be benefited by a sojourn at Aiken. In support of the greatly beneficial effect produced by a residence at Aiken upon cases of pulmonary phthisis, the following statistics from the pen of Dr. Geddings are subjoined. Out of a total number of 113 cases of this disease treated at Aiken during a period of three years there were: Arrested, 17 cases, or 15.2 per cent.; improved 50, or 44.6 per cent.; unchanged 10, or 8.8 per cent.; the number of patients who grew worse was 29, or 25.2 per cent.; the number of those who died was 7, or 6.2 per cent.

These statistics, which certainly speak well for the climate of Aiken, were originally published in an article contributed by Dr. Geddings to the New York *Medical Record* (January 14, 1882).

It is almost superfluous to call attention to the fact that inasmuch as cases of so grave a disease as pulmonary phthisis derive so much benefit, patients suffering from the less serious and less severe affections of the respiratory system, such as laryngitis and naso-pharyngeal catarrh, may be expected to derive, and, as experience has proved, actually do derive an equal and even greater degree of such benefit from a resort to this favored spot during the colder, damper, and more changeable months of the year.

To illustrate the comparatively small amount of variability in temperature possessed by the climate of Aiken, the following figures are quoted from "Appletons' Handbook of Winter Resorts." The figures show the mean variation of temperature in twenty-four hours for the seven colder months of the year. The length of the period of observation, whether for one year or for several years, is not stated by the writer in "Appletons' Handbook," but the figures were "compiled from reports on file at the Signal Office, Washington."

MONTH.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.
Daily variation......	10.03°	17.03°	18.26°	18.06°	12.45°	19.14°	17.64°

A table showing this same factor of daily mean variation of temperature during the year 1873, but which, unlike the former table, is based upon the tri-daily observations at the hours of 7 A.M., 2 P.M., and 9 P.M., instead of upon observations recorded from the maximum and minimum thermometers, is also given by Dr. Geddings on page 23 of the little pamphlet entitled, "Aiken, S. C., as a Winter Resort." For further illustration of this same point these figures of Dr. Geddings are likewise herewith appended.

OBSERVATIONS OF 1873.

MONTH.	Jan.	Feb.	March.	April.	Sept.	Oct.	Nov.	Dec.
Mean diurnal range.......	12.96°	10.92°	13.45°	15.66°	10.46°	14.19°	12.45°	13.00°

The following figures, showing the mean temperature at Aiken for each of the twelve months, for each of the four seasons, and for the year, are quoted from "Smithsonian Contributions to Knowledge," No. 277. The observations upon which these figures are based were taken at 7 A.M., 2 P.M., and 9 P.M., (by Messrs. H. W. Ravenel, J. H. Cornish, and Newton), and extended over a period of seventeen years, from January, 1853, to December, 1869.

January.......	44.15°	July..........	78.80°	Spring........	61.32°
February......	47.83°	August........	77.19°	Summer.......	77.36°
March.........	53.22°	September.....	72.23°	Autumn.......	61.96°
April..........	61.49°	October.......	61.80°	Winter........	45.82°
May...........	69.25°	November.....	51.84°	Year..........	61.61°
June..........	76.08°	December.....	45.48°		

The mean relative humidity for the year at Aiken, according to a footnote appended to his observations concerning the climate of that place, which are given by Dr. Geddings on pages 19 to 30 of "Aiken, S. C., as a Winter Resort," is fifty-eight per cent. The chart next following gives meteorological data of various sorts for the six months of the year during which Aiken is commonly resorted to by invalids, and for its careful filling out the writer is much indebted to Dr. Geddings, through whose kindness the proper figures were obtained.

The water-supply at Aiken is chiefly derived from wells, which have to be sunk to a depth of about one hundred feet. In its character this water is pure and palatable, and it is said to be quite free, not only from all admixture of animal or vegetable matter, but also from any mineral ingredient except iron, a certain proportion of which is to be found in the water derived from some of the natural springs. The sandy roads leading in various directions through the pine woods afford ample facilities for driving and riding.

HOTELS, ETC.—Aiken is justly celebrated among the health resorts of the Southern States for the excellence of its hotels. The largest and best known of these is the Highland Park Hotel, which not only provides for its guests an abundant and well-supplied table, but also possesses many other conveniences, and stands upon a reservation of ground extending over no less than two hundred and fifty acres of forest-land. The Park Avenue Hotel is under the same management and proprietorship as the Highland Park Hotel. Besides these two, the contributor of the article on Aiken, in "Appletons' Handbook of Winter Resorts," makes favorable mention of the Aiken Hotel, and of the Clarendon, and further states that "a group of neat cottages" exist, which are let to families, and that "there are many boarding-houses in the town, charging from ten dollars to twenty dollars a week." In reply to an inquiry concerning the educational facilities existing at Aiken, Dr. Geddings informs the writer, in a letter bearing date of January 30, 1885, that "there is no first-class school for advanced pupils, but, on the other

hand, there are abundant opportunities for the best private instruction in English, classics, and music." In conclusion, it may be added that, situated as it is upon the line of the South Carolina Railroad, Aiken is extremely easy of access to travellers from all parts of the United States.

Climate of Aiken, S. C.—Latitude 33° 32", *Longitude* 81° 34"—*Period of Observations,* 1873 *to* 1884—*Elevation of Place above the Sea Level,* 565 *feet—Name of Observer,* W. H. GEDDINGS, M.D., *Aiken, S. C.*

	A. Mean temperature of months at hours of			AA. Average mean temperature deduced from column A.	B. Mean temperature for period of observation.		C. Average maximum temperature for period.	D. Average minimum temperature for period.	E. Absolute maximum temperature for period.		F. Absolute minimum temperature for period.		G. Greatest number of days in any single month on which the temperature was at the average monthly minimum and below.	H. Greatest number of days in any single month on which the temperature was at the average monthly maximum and upward.
	7 A.M. Degrees.	2 P.M. Degrees.	9 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January..	42.21	54.35	47.74	48.01	56.00	41.38	71.00	20.80	78	65	27	08	3	6
February.	43.24	56.99	49.75	49.93	55.27	45.85	73.54	26.27	82	66	34	18	4	7
March....	49.03	63.82	56.88	56.40	61.87	51.48	78.44	30.64	84	74	39	23	4	6
April.....	57.12	70.80	62.72	63.34	66.13	60.63	84.00	41.57	89	82	48	40	2	4
November	48.63	60.87	53.02	53.88	59.80	50.83	76.72	27.63	81	71	36	22	2	7
December	41.81	54.25	46.81	47.42	54.83	37.73	70.45	20.81	75	61	31	03	3	5
Spring....	(Feb., March, and April.)			56.55	58.74	53.44	......	......	......	......	......	......	....	....
Winter...	(Nov., Dec., and Jan.)			49.77	53.06	47.06	......	......	......	......	......	......	....	....

	J. Range of temperature for period.	K. Mean relative humidity. (For two years only.)	L. Average number of fair days.	O. Average rainfall.	R. Prevailing direction of wind.	S. Average velocity of wind in miles per hour.
	Degrees.	Per cent.		Inches.	From	Miles.
January....	70	65.03	19¾	3.64	S.W. and W.	3.60
February...	64	54.13	19¾	3.26	S.W.	3.70
March......	61	49.00	21	4.86	S.W.	3.28
April.......	49	53 90	23½	4.71	S.W.	No obs.
November..	59	63.67	19¾	3.43	S.W.	2.46
December..	72	61.59	20¼	3.28	S.W. and W.	3.23
Spring......	71	52.34	64¼	12.83	S.W. and W.	3.49
Winter......	78	63.43	59¾	10.35	S.W.	3.09

NOTE.—Aiken being a voluntary station of the United States Signal Service, the hours of the tri-daily observations of temperature differ from those observed at the regular stations. The term "fair," in column L, is not employed in the purely technical sense adopted in the charts from regular stations. Attention is called to the fact that in this chart February is reckoned among the Spring months, and November among the Winter months.

Huntington Richards.

AINHUM. A disease, supposed to be a form of scleroderma, occurring in one or more of the extremities, and resulting frequently in gangrene or spontaneous amputation of the distal end of the affected member. It was first clearly described by J. F. da Silva Lima, a physician of Brazil, in 1867 ("Estudo sobre o ainhum," *Gaz. Med. de Bahia,* No. 1, 1867), although isolated cases had been previously reported by others. In the cases seen and studied by him, the disease was confined to the negro race, and the morbid process involved only the little toe of adults. It began as a slight depression on the plantar aspect of the metatarso-phalangeal articulation of the fifth toe, gradually increasing in extent until a distinct sulcus was visible, entirely surrounding the digit. The constriction growing deeper, the distal end was, in time, separated from the foot, retaining its connection only by a slender pedicle. The separated toe was sometimes unchanged in appearance and structure, but more frequently the phalanges became atrophied, and in time disappeared, leaving only an oval-shaped fleshy knob, united to the foot by a fibrous pedicle. Finally, the pedicle itself was destroyed, and amputation of the toe was completed. The limitation of the disease to the fifth toe of adult negroes, as maintained by Silva Lima and other writers on the subject, in Brazil, is too narrow, for later observers have seen an identical process taking place in others than adult negroes, and involving different members. It may occur in any race, and at any age, and may be located in any one or several of the fingers or toes, or even in the legs. It may also take place in intra-uterine life, being probably the most frequent cause of congenital amputations. The progress of the disease is usually very slow, and it seems at times to become arrested before any very serious changes have been produced in the distal portion of the affected extremity. The morbid process may even cease before the constriction embraces the entire circumference of the limb, so that the sulcus forms an imperfect ring of greater or less extent.

In a case of ainhum examined by Guyot, the morbid process was found to be located in the deeper layers of the dermis, and to consist in an aggregation of fibrous bands, running in a direction at right angles to the axis of the limb. The band was thickest at the centre, becoming gradually thinned at each side until it was lost in the fibrous tissue of the integument. These fibres contract slowly, like cicatricial tissue, gradually constricting the limb, as would an elastic ligature, and by compressing the vessels and nerves, inducing degenerative changes, and, finally, death of the parts beyond. The affection arises independently of traumatism or other external causes, and is supposed to be due to a disturbance of the trophic nervous centres. If the disease is seen to be advancing, and to threaten the function or the life of the limb, an endeavor should be made to arrest its progress by practising one or more incisions through the constricting band in a line parallel to the axis of the limb. If this procedure do not suffice, the fibrous band should be dissected out. An incision is to be made on either side, parallel to the sulcus, and the intervening portion of integument is then removed, care being taken to leave none of the transverse fibres. The gap remaining after the exsection of the sclerosed strip of skin is bridged over by direct approximation and suture of the edges of the wound. Only one-half of the circumference should be removed at one time, the remaining portion being excised at a subsequent operation.

For a more extended description of this disease the reader may consult: Fox and Farquhar, "On Certain Endemic and other Skin Diseases of India," London, 1876; L. P. Despretis, "Étude sur l'ainhum," Mont

pellier, 1873; P. Reclus, "Amputations congenitales et Ainhum," Paris, 1884; *L'Union Médicale*, October 18, 23, and 25, 1883; and other French, Spanish, and Portuguese periodicals of recent years. *Thomas L. Stedman.*

AIR. The atmosphere, according to the chemist, consists of a mixture of two gases, oxygen and nitrogen. The former is active in its properties, combining with many susceptible elements, and especially with the carbon and hydrogen of devitalized organic matter, constituting, according to the rapidity of the process, either oxidation or combustion, and with the same elements in the living tissues of animals constituting one of the essentials for the continuance of life. The latter is passive, negative, and merely diluent.

Oxygen forms 20.96 per cent. by volume of the gaseous mixture; and this proportion is preserved in all parts of the atmospheric ocean. Specimens taken from the sea level, and from the mountain-tops give practically the same percentages, a result due to the constant motion produced by cosmical forces, and especially to the power of diffusion or penetration into inter-molecular areas which gaseous molecules are known to possess. Reference is here made only to the general constitution of the air. Samples taken from enclosed localities where deteriorating agencies prevail, as in an unventilated and occupied school-room, church, theatre, etc., will, of necessity, show a diminished percentage of oxygen.

A certain small percentage of the oxygen of the air exists in the form of *ozone*, a peculiar modification of oxygen which, although much studied since first discovered by Schönbein in 1840, has yet to have its chemical and natural history fully written. Its nature is uncertain, but it is generally regarded as O_2O. The quantity present in the air cannot be determined, and even its existence is at times indicated with doubt by the iodized starch papers which have been largely used for its detection, as they are affected by other matters, as nitrous acid and peroxide of hydrogen, occasionally present in the atmosphere. Iodized litmus papers have been shown by Dr. Fox to be of value as a qualitative test, and as indicating comparative quantities when known volumes of the air are aspirated over them. It is certain, however, that ozone has stronger affinities than ordinary oxygen, and that oxidation goes on more rapidly in its presence than in its absence. It undoubtedly destroys the volatile substances which are evolved during the putrefactive process. Where foul organic odors are present, ozone is absent. Hence, when the presence of ozone is indicated by the test-papers, the air is regarded as free from organic contaminations susceptible of oxidation. But there are grounds for supposing that the specific contagia are not destroyed by it. (See Malaria.)

In the atmosphere, however, the chemist recognizes the existence of small and varying quantities of matters accidentally present, such as carbonic acid, ammonia, watery vapor, and organic matter.

The *carbonic acid* is produced by the oxidation of carbon in dead and living tissues, and its percentage varies with the local causes which determine its production. Thus it is greater in the alleys and streets of a city than in the open country; and, as this gas is soluble in water, its proportion varies with the hygrometric and other conditions, being greater in a damp atmosphere, before rain has fallen, than in the air of the same locality after the watery vapor has been precipitated. The wind and the diffusive power of gases tend to equalize the percentage; but, as production is constant in certain localities, the air of these must always show a larger proportion of this gas than that of others remote from such sources. It is generally stated that 4 volumes of carbonic acid are found in 10,000 volumes of atmospheric air; and this, according to the writer's experience, may be accepted as the average. In 1881, in connection with a report on the ventilation of the public schools of Washington, D. C., he found in the air of the streets of the city, a little over or a little under 4 volumes in 10,000; but on one occasion 4.9 volumes were obtained, and on another 2.2 volumes. Two years before this he got similar results from the air of the Capitol grounds, while engaged in an investigation having reference to the ventilation of the House of Representatives; and, in the spring of 1874, in a series of examinations into the ventilation of soldiers' quarters, at Fort Bridger, Wyoming Territory, he found a steady and gradual decrease, day by day, as the season advanced, from 4.5 to 2.6 volumes per 10,000.

Some points have been determined concerning these tides in the carbonic acid volumes, especially by the observations of De Saussure; but, practically, no one can as yet predicate, from the experiment of one day, the probabilities as to the result of that of the next. Carbonic acid in the air of dwellings has, as will be shown hereafter, an important bearing on the subject of ventilation.

Ammonia emanates and is diffused from putrefactive processes in progress on the surface of the earth. It is also produced from the nitrogen of the atmosphere by electric agency, as during thunder-storms. Its quantity is variable, but 0.1 mm. in a cubic metre of air is a not unusual amount. This corresponds to a grain in about 23,000 cubic feet. In a series of analyses of the free external air, preliminary to an investigation of its abnormal conditions, the writer frequently obtained this quantity. Rain washes the ammonia from the air to the surface of the earth, and in the rainfall it may always be detected and measured. Its quantity is increased during thunder-storms. It varies from less than 0.2 to more than 0.5 mm. per litre (one grain in from 34 to 86 U.S. gallons). In dealing with cubic feet of air the ammonia is necessarily a very minute quantity, but when the annual rainfall over a tract of country is made the basis of calculation, the subject becomes one of importance in agricultural chemistry.

The ammonia of the air is condensed on exposed surfaces, and R. A. Smith has suggested that the quantity of ammonia deposited on a given surface in a given time may be taken as an exponent of the sanitary condition of the atmosphere. A glass or other surface which has been exposed for some time in an unventilated bedroom, when washed with pure water, will show in the washings the presence of a readily determinable quantity of ammonia; but the attempt to demonstrate the relative purity of atmospheres by the quantity deposited on equal and similar surfaces in equal periods of exposure meets with failure unless the temperature, the hygrometric condition, and the air movement are the same in both instances. This concurrence of similar conditions is difficult, if not impossible, to obtain in practice. The writer failed by this method to show the presence of sewer air in an atmosphere in which it was known to be present.

Watery vapor is constant in its presence in the atmosphere, but in such varying quantities that it is viewed by many as an accidental constituent. Its importance, however, not only in the preservation of the purity of the atmosphere, but as a preservative of the vitality of all the organisms submerged in it, is so great that it must be regarded physiologically as an essential. The capacity of air for holding aqueous vapor is limited and varies with the temperature. When air of a given temperature is so permeated with aqueous vapor that no more can be taken up, it is said to be saturated for that temperature. Thus air at 0° C. (32° F.) will take up and hold 4.875 grammes of aqueous vapor in one cubic metre (equivalent to 2.13 grains in a cubic foot). But if this same air is attenuated by increasing its temperature to 21.1° C. (70° F.) its capacity for holding the vapor of water will be increased and a cubic metre will not be saturated until it contains 18.334 grammes (or 8.01 grains in the cubic foot). Precipitation of vapor occurs when the air is cooled to a temperature below that which is needful to enable it to retain the vapor which it contains. If a cubic metre of air at 21.1° C. holds only 4.875 grammes of aqueous vapor, precipitation will not take place until the air has been cooled to 0° C.

The degree of temperature at which moisture begins to be deposited from air is called the *dew-point.* When air is saturated, its temperature and the dew-point coincide. The quantity of vapor which air is capable of re

taining has been accurately determined for all ordinary temperatures. It is, therefore, only needful to ascertain the dew-point to learn, not only how much vapor the air contains, but, which is of more importance, how much more it is capable of taking up. As this latter quantity varies with the temperature and the difference between that temperature and the dew-point, medical climatologists have endeavored to effect a uniformity in their records by expressing the results of such observations in terms of *relative humidity*, saturation being represented by 100. The dew-point may be obtained, after Regnault's method, by evaporating ether in a test-tube containing a sensitive thermometer, and noting the temperature when the surface of the tube becomes dimmed by deposited vapor from the air. But it is usually calculated from the difference between the dry and wet bulbs, and the relative humidity is obtained therefrom by the use of Glaishers' tables.

The air constituents which have been mentioned must be regarded, from the scientific and sanitary point of view, as individually essential to the constitution of the atmosphere. The oxygen is vital to animals, its quantity being preserved by the evolution from vegetation and the equilibrium established between these two kingdoms of nature. The carbonic acid is vital to vegetation, being the source of much of the carbon solidified in its tissues; its quantity is preserved by the evolution from animals and by the retrogressive metamorphosis of the organic carbon of devitalized tissues. The ammonia is needful to the building up of organic structures by vegetable life, which afterward figure in the life-history of the animal kingdom, and which, when ultimately overtaken by death, are returned to the ammoniacal condition by the agency of microscopic organisms. The nitrogen is primarily a diluent presenting the oxygen to the animal kingdom, and the carbonic acid to vegetation, in the strength best suited for their respective needs. Speedy death occurs to the animal organism exposed to an atmosphere of undiluted oxygen from exaggeration of the vital actions. Presumably a similar effect would be produced on the vegetation of to-day by a carbonic acid atmosphere, for, if we look back through the geologic eras to the time when a carbonic acid atmosphere enveloped the earth, we find the genera then living wholly different from those which are now their successors under different conditions. But there is ground for supposing that the inorganic nitrogen of the air is a store from which the organic kingdoms may draw supplies. Nitrogen is transformed into ammonia and nitrous acid by electrical agency, and thus becomes susceptible of assimilation by the vegetable kingdom. The name *azote*, originally applied to this gas by the chemists, because animal life could not be sustained in it, is a misnomer. Without nitrogen there is no life. Some of the products of vital action, as the fats and starches, contain no nitrogen, but the active tissues of vitality which elaborated these carbonaceous products are nitrogenous. Watery vapor prevents desiccation. Without a certain relative humidity life, vegetable or animal, would be an impossibility. As the fish dies when taken from the water, though in a medium which is richer in oxygen than is its natural habitat, so would all air-breathing organisms perish were the humidity of the atmosphere removed. But this water, by its absorption into and deposition from the atmosphere, under altered conditions as to temperature, exercises another and most important function. Among what may be considered, in accordance with our present knowledge of vital actions, as the purely accidental substances found in the atmosphere, particulate matter in fine division, in other words, the dust of the earth, occupies a prominent place. As the earth is composed of organic and inorganic, living and dead matters, its dust is of similarly varied composition. Among the various species of the genus dust are some which, as will be shown hereafter, are exceedingly deleterious to animal life; but the greater number in the quantity usually present in the air are individually and collectively harmless. Nevertheless, without the aqueous vapor, there is no provision of nature by which life may be preserved from suffocation by this otherwise harmless dust. With the reduction of the atmospheric temperature to a point below the dew-point, water is liberated and precipitated to the surface of the earth, carrying with it all particulate matters which would otherwise accumulate without end. The clearness of the atmosphere after a rain-storm, which has been preceded by a period of dry weather, is a matter of common observance, and can be readily understood. The impurities are washed to the surface. Rain-water is the sewage of the atmosphere.

The matters occasionally or accidentally present in the atmosphere are gaseous or solid. Of the former, carbonic acid in excess of the average quantity must be regarded quantitatively as the most important. Its sources are organic decomposition as occurring in the soil, animal respiration, and the combustion of fuel. Hence it is found in excess or as an impurity at or near the surface of the ground in the narrow streets of closely built cities, and within the walls of occupied buildings. Carbonic acid is probably harmless *per se*, unless in very unusual quantities, but as its sources, in most instances, evolve also matters which are harmful, its presence is of much importance. Coming from the interstices of the ground or from the sewers, carbonic acid may be accompanied by specific miasms. In the former instance it may be suggested that the specific miasms, being particulate, are removed by the filtration which the air undergoes. It is well known to every experimenter that a plug of cotton-wool will protect a sterilized culture-fluid from impregnation by the germs of putrefaction—that is, that the wool will act efficiently as a filter when the air-current is only such as is caused by variations in temperature and barometric pressure. Professor Pumpelly has shown that asbestos, sand, and other dry filters are efficient against putrefactive agencies even when the air is drawn rapidly through them. Moreover, the writer knows, by experiments performed for the National Board of Health, and as yet unpublished, that the nitrogenous matters of sewer, garbage, and marsh airs are particulate and susceptible of removal by filtration. But it remains to be proved that such nitrogenous particulate substances are removed by a filtration through the organic matrix, the soil, in which they are multiplying. Besides, in this question, evaporation from the surface is involved as well as filtration through the substance. The passage of air through and from the soil promotes evaporation from the surface, which carries with it the miasmatic exhalation. Hence may be inferred the inadvisability of furnishing *cellar air*, or air introduced by tunnels into a building for purposes of ventilation. In fact cellars, in default of an impermeable lining, should have a free circulation of air separate from the ventilation system of the superimposed building.

Carbonic acid from the consumption of fuel and gas, while injurious by diminishing the proportion of oxygen in the air furnished for respiration, may be accompanied by other and more deleterious gases, such as carbonic oxide and sulphurous acid. One cubic foot of gas, according to Parkes, destroys in its combustion the entire oxygen of eight cubic feet of air. Carbonic acid as the result of animal respiration is accompanied by organic exhalations which are well known to be deleterious, producing headache and febrile action when the exposure is of short continuance, and predisposing to pulmonary affections, phthisis, and typhous conditions when the exposure is habitual. Specific miasms or contagia, if present, are generally concentrated in proportion to the percentage of expired carbonic acid in the air. Hence the *examination of the air* of an occupied building usually resolves itself into a determination of the amount of carbonic acid present in it; not because this gas is of much importance in itself as compared with the organic matters which are eliminated with it from the human system, but because both being the result of the same vital processes, pulmonary and cutaneous exhalation, the amount of the one may be taken as an expression of the quantity of the other. These organic matters are susceptible of separation into particulate and gaseous; the vital qualities of

the former may be examined microscopically by cultures and by inoculation, and the elementary analysis of both may be effected with the utmost accuracy; but the collection of the organic matter for such quantitative experiments involves a tedious filtration, during which the character of the air to be examined may become materially changed, and when collected the experimental processes to which it must be subjected requires so much care, time, and experience in this special line of sanitary work that in practice the organic matter is seldom determined. The carbonic acid, on the other hand, is quickly collected, readily and accurately estimated by any one who possesses experimental tact, and an experience of general volumetric analysis. It has therefore become the exponent of the *respiratory impurity of air;* the increase in its amount over that present in the external air being a measure of the respiratory use to which the air has been applied and of its fitness or unfitness for further use. In estimating the carbonic acid an alkaline solution of baryta or lime of known strength is used for its absorption, and the loss of alkalinity, as subsequently determined by some other acid, gives the figures from which the absorbed carbonic acid may be calculated.

The practical details are as follows: A solution of pure oxalic acid is made of such strength (2.864 grammes per litre) that one gramme will neutralize as much caustic baryta as may combine with one milligramme of carbonic acid. A baryta solution of equivalent strength, one gramme of the one neutralizing one gramme of the other, is then made and immediately transferred to bottles of from 50 to 60 c.c. capacity (two-ounce vials), each of which is corked securely and weighed, and the total weight of the bottle and its contents is marked upon the label. The air to be examined is collected in a clean and perfectly dry clear glass bottle or narrow-mouthed jar, the capacity of which is accurately known. Ten-litre bottles are large enough to give accurate results. A rubber tube and small bellows are conveniently used in filling the jar with the air to be examined, but care must be taken that the air entering by the valve of the bellows is not contaminated by any direct respiratory streams from individuals present. As soon as the charge of air has been effected, one of the prepared baryta vials is carefully uncorked and its contents poured into the jar, which is then closed by an accurately ground stopper, or preferably by a tightly fitting rubber cork. The baryta solution is then shaken in the jar, and made to flow all over its interior to promote its contact with the contained air; but to insure thorough absorption of the carbonic acid the jar is usually permitted to stand until the following day before determining the loss of alkalinity. Meanwhile the volume of the air operated on is ascertained from observations made at the time the air was collected. The height of the barometer and of the dry and wet bulb thermometers must be known, and the quantity of baryta solution introduced into the jar. The last is obtained by weighing the now empty vial in which it was stored and deducting this weight from the gross weight marked on the label. The quantity in grammes of the baryta solution employed must be deducted as cubic centimetres from the known capacity of the jar. But in order that experimental results may be susceptible of comparison it is necessary to express the air-volume in the space which it would occupy when dry at zero Centigrade and under a pressure of 760 millimetres of mercury. Increased pressure diminishes the volume of air, increased temperature expands it, and the pressure of the watery vapor present must also be taken into account. The temperature observations furnish the dew-point, and through it from the observations of Regnault the pressure or tension of the aqueous vapor may be obtained. If p represents this pressure, t the temperature in Centigrade degrees, b the barometric height in millimetres, and V the capacity of the jar, minus the number of cubic centimetres of baryta solution introduced, the corrected volume will be equal to

$$\frac{V(b-p)\,273}{(273+t)\,760}.$$

Next day the liquid contents of the jar are transferred to a small beaked flask or alkalimeter, and the weight of the flask and its contents is noted, that, by again weighing, the loss of weight may indicate the quantity used in the subsequent experiment. Ten grammes of the oxalic solution are weighed into a small beaker and colored with a few drops of tincture of litmus. Into this the deteriorated baryta solution (after the carbonate present has settled) is dropped from the alkalimeter rapidly, until a haziness is developed, and after this more slowly until the last drop changes the color to a dark purple. The oxalic acid has been neutralized, and the weight lost by the alkalimeter gives the quantity of the baryta solution used in effecting the neutralization. Let it be supposed, for example, that 50 grammes of the solution were introduced into the jar, and that 25 grammes of it are now required to neutralize 10 grammes of the standard acid, the total of 50 grammes will suffice to neutralize only 20 grammes of the oxalic solution, while before absorbing the carbonic acid of the bottled air it was capable of neutralizing 50 grammes. There has therefore been removed by this carbonic acid as much baryta as would neutralize 30 grammes of the oxalic test, or, in other words, 30 milligrammes of carbonic acid were contained in the air which was the subject of the experiment.

The weight of the carbonic acid in milligrammes when multiplied by the factor .50685 gives expression to its volume in cubic centimetres. It must be remembered, however, that this volume of carbonic acid is not all carbonic impurity, but includes that which is naturally present in the air. When the result of a cotemporaneous experiment on the external air has been deducted, the remainder indicates the carbonic acid due to imperfect ventilation.

An easily applied method of ascertaining whether a given air contains more than a certain number of volumes of carbonic acid per ten thousand is based on the turbidity caused in lime-water by the precipitated carbonate. If a half-ounce of this liquid is shaken up in an eight-ounce vial filled with the air to be examined, the appearance of turbidity indicates the presence of eight or more volumes of carbonic acid in ten thousand volumes of the air, and that the arrangements for ventilation in the apartments which furnished the air are not as satisfactory as could be wished. Bottles of various sizes are used by the operator in conducting this, the *household method of sanitary air analysis,* and from the capacity of the bottle in which a just visible turbidity is produced the volumes of carbonic acid per ten thousand become known.

In another method, the *minimetric,* air is introduced in small quantity into a vial containing lime or baryta solution, which is well shaken, with gradual additions of the air, until the liquid shows a certain loss of transparency, when the carbonic acid is calculated from the quantity of air needful to the production of this result.

These, although pretty experiments, and described in full by most sanitary writers, have not come into general use, because they are not required. As they yield results which are only approximative, they cannot take the place of the accurate determination needful in a scientific inquiry, while, as rough and ready methods, their results convey no more information of practical value than may be gathered unpretentiously by the sense of smell. A well-ventilated room should not have more than one or two volumes per ten thousand in excess of the external air, equalling a total of five or six volumes. When the carbonic acid amounts to seven volumes, a want of freshness is recognized on entering. When nine, ten, or more volumes are present, the organic odor becomes manifest.

Although the carbonic acid, as has been stated, is generally accepted as a measure of the respiratory impurity, it is not an accurate one, for it is more readily diffused and carried off by ventilating currents than the organic exhalations which accompany it from the human system. Whence it comes that the continued occupancy of an apartment may give rise to organic odors in its atmosphere, although carbonic acid may not be present in large quantity. The writer has frequently

detected the organic odor in barrack-rooms some time after the men had quitted them, when the carbonic acid, on account of open doors and windows, was but little in excess of that found in the open air. The exhalation appears to adhere to walls and other surfaces, and textures, and to require time for its dissipation.

But, while the carbonic acid is not an accurate measure of the organic contamination in the air of occupied buildings, its estimation affords the best means of testing the *efficiency of the ventilation.* Sanitary inspectors do not recognize this fact. Sanitary chemists have not brought it prominently into notice. When questions of ventilation are to be settled, Cassela's air-meter is used, and the air movement is calculated from its indications and the areas of inflow and exit. The inspector shows that so much air has entered or that so much has escaped, to be replaced of necessity by a corresponding volume of fresh air through the inflow ducts. But this is not enough. It must be shown that the air introduced has effected the purpose for which it was introduced. This may be done by a calculation based on the amount of carbonic impurity found by experiment. It is needful to know the average rate at which carbonic acid is eliminated from the person. This evolution varies according to conditions of rest or activity. Professor Parkes states the yield at from twelve to sixteen cubic feet in twenty-four hours, or from .5 to .66 of a cubic foot per hour. Huxley gives three hundred and sixty feet as the volume f air expired daily, and, as the air of expiration is known to contain four per cent. of carbonic acid, this is equivalent to an hourly production of .6 of a cubic foot. Other experimenters have arrived at similar results. This is a convenient number for calculation, as it corresponds with .01 of a cubic foot per minute. The capacity of the room must also be ascertained, and in exact calculations deduction should be made for the body bulk of the occupants and for the furniture. The time during which the deterioration has been going on is another factor entering into the calculation.

The carbonic evolution, .01 cubic foot per minute per person, multiplied by the number of minutes, gives the amount of the carbonic impurity generated. When this is divided by the carbonic impurity found by experiment in ten thousand volumes of the air, the quotient multiplied by ten thousand will express, in cubic feet, the volume of the air with which the respiratory products have been diluted. But, as the air-volume in the room has contributed to the dilution, its capacity has to be deducted from the total to obtain the amount of the inflow.

Thus, if the data consist of 50 persons, 50 minutes, 7,000 cubic feet, and a carbonic impurity experimentally found of 10 volumes:

$.01 \times 50 \times 50 = 25$ cubic feet of carbonic acid expired.

$\frac{25}{10} \times 10{,}000 = 25{,}000$ cubic feet of air required for the dilution.

$25{,}000 - 7{,}000 = 18{,}000$ cubic feet of inflow.

$\frac{18{,}000}{50} = 360$ cubic feet of inflow per minute.

$\frac{360}{50} = 5.1$ cubic feet of inflow per minute per person.

The inflow being known, other questions which need only be suggested, may be answered. An experiment has been made on the air of a room which contained only fifty persons, although seated for one hundred; what would have been the result had all the seats been occupied? The occupation of the room at the time of the experiment had continued but sixty minutes; what would have been the result had the occupation lasted six hours?

In practice it is often found that the inflow, as determined by the anemometer, is much greater than that obtained from the chemical results. That the air enters is certain, and that it fails to be utilized in diluting the expired air, is equally so. A want of diffusion must be inferred in explanation. In one of the schools of Washington, D. C., 800 cubic feet per minute entered the room, while but 324 cubic feet contributed to the ventilation. The cause in this instance was manifest. The temperature of the incoming air was so great that it rose immediately to the ceiling, whence it was drawn off by the lowered windows and foul air-flues. Somewhat similar conditions prevail in the Hall of Representatives in our National Capitol. Although the floor is largely and generally perforated for the inflow of fan-driven air, certain of the ducts leading to these perforations carry a large proportion of the incoming air, while others bring but little. Over some of the gratings there is a vigorous current, over others the inflow is small. The impetus in the one case carries the air upward until it reaches the area influenced by the aspiration of the louvres on the roof, whence it is carried through the perforations in the ceiling without having been distributed in the body of the hall. While the spaces in front of the Speaker's desk, and in the centre of the hall are well ventilated by this upward current, the air of the sides and galleries is more or less stagnant. The volume of air which enters is sufficient to effect a satisfactory ventilation, but it is not distributed. The galleries are close and stuffy, while certain of the occupants below may feel chilly in the uprising current.

The gaseous products of fuel and gas consumption contain traces of *carbonic oxide,* if the oxidation is not complete. This gas is highly poisonous, entering the blood and rendering the red corpuscles incapable of performing their function, even though pure air be afterward supplied. Death is the result of asphyxia. In rooms heated by stoves the headache, languor, and oppression occasionally produced are due to the escape of this with other gaseous products through the open stove-doors and leaky joints. Some experiments of St. Claire Deville and Troost indicated that the carbonic oxide might even pass through the pores of cast iron when the metal became strongly heated. The French Academy, therefore, caused an investigation to be made of this subject, and the conclusion was reached that carbonic oxide does pass through the metal when its temperature reaches a dark-red heat. Since these experiments air heated by furnaces or cast-iron stoves has been regarded as injurious. But doubt has been thrown upon the results of the French chemists by several later experimenters, and particularly by Professor Remsen, of Baltimore, Md., who has shown some possible sources of error, and who, having guarded against these, has concluded that, while carbonic oxide may be present in the air of furnace-heated rooms, it must exist in quantities so minute that it is questionable if it can act injuriously on the health of those who breathe it.

Carburetted hydrogen and sulphurous acid are liberated during combustion, but in such small quantities that they need not be considered as influencing the health.

The gases evolved during the putrefaction of organic matter, as in impure soils, manure piles, cesspools, vaults, drains, and sewers, consist of carbonic acid, nitrogen, sulphuretted hydrogen, ammonium sulphide, carburetted hydrogen, and organic vapors. The action of the sulphur gases on the animal system has been demonstrated experimentally by Barker on dogs and other small animals. *Sulphuretted hydrogen* produces vomiting and diarrhœa, prostration and coma, which last, like the effects of carbonic oxide, persist after removal from the contaminated atmosphere. The exhaustion and coma continue, and death results if the impression fixed on the blood is sufficiently powerful. But, while this undoubtedly occurred in the subjects of Dr. Barker's experiments, it is well known that men may breathe with impunity for a time a sulphuretted atmosphere many times stronger than those employed by him. *Sulphide of ammonium,* according to this experimenter, caused vomiting and febrile action, quickly followed by the development of a typhoid condition. In fact, he considered the sulphuretted hydrogen similar in its action to the poison of typhus, and sulphide of ammonium to that of typhoid fever.

Chronic poisoning by sulphuretted hydrogen manifests itself, according to some observations, by gradual prostration, emaciation, and anæmia, with headache, foul tongue, anorexia, and the occasional eruption of boils, but it is not certain that these symptoms are due to this gas and not to organic miasms which may accompany it.

The action of the more *complex organic vapors* given off during decomposition has not been determined. The dogs subjected by Dr. Barker to the cesspool air were all more or less affected, the symptoms being those of intestinal derangement with prostration, heat of surface, distaste for food, and those general signs which mark the milder forms of continued fever common to "the dirty and ill-ventilated homes of the lower classes of the community." But the sulphur compounds already mentioned contributed to these results.

Even the constitution of these organic vapors is not known with certainty. Dr. Odling distilled half a gallon of the liquid contents of a cesspool until all alkaline matters had come over. He treated the fetid ammoniacal distillate with hydrochloric acid, and afterward precipitated with platinum. The platino-chlorides of the organic alkalies were found to crystallize in well-defined, flattened, orange-colored tablets, evidently not the platino-chloride of ammonium. Incineration of this platinum salt yielded 41.30 per cent. of the metal, while the platino-chlorides of ammonium, methylamine and ethylamine gave respectively, 44.36, 41.64, and 39.40 per cent. of platinum. The salt formed from the *carbo-ammoniacal vapors* was analogous in composition to that formed with methylamine. But inasmuch as the crystals were more like those of the ethyl salt, and as a mixture of the ethylamine and ammonium salts would correspond in percentage composition to that obtained from the distillate, he supposed that the sewage emanations were ammoniacal and ethylic.

A series of experiments made by the writer has shown that the volatile matters evolved during the fermentative changes in organic substances are of two different characters, the one vaporous and ethylic, but not containing nitrogen if separated from the ammonia with which it is volatilized and condensed, and the other volatile, carbonaceous, and solid, concreting on distillation into white, soft, and greasy particles. The former has a dull, mawkish, not positively unpleasant, odor, the latter a strong and intensely disagreeable smell.

The *solid matters* disseminated in the air consist, first, of minute particles of inorganic matter, such as soot, amorphous silicates, irregular fragments of hard mineral dust, and crystals of salts, many of which have not been identified; secondly, of the detritus of decaying vegetation, starch-cells, epidermal hairs, filaments from the pappus of the compositæ, pollen grains, etc.; thirdly, of fragments of animal tissues, epidermal and epithelial scales, woolly fibres, plumelets of feathers, butterfly scales, and other débris of insect life, etc.; and fourthly, of micrococci, bacilli, the spores of fungi, and rarely the germs of infusorial life. It is probable that among the micrococci and spores are included the essence of many of the specific diseases which affect the vitality of the higher organisms. (See Bacteria.)

The microscope has separated the organic matter of the air into the living and the dead, the animal and the vegetable, and biological experiment has determined the life history and function of many of these living forms. On the other hand, chemistry has done but little to perfect the *organic analysis of air*. With known methods of analysis the results obtained by the expenditure of much time and care are of small value. If an air-specimen contains an unusual amount of the organic elements, it may be correctly considered as impure, but the nature of the impurity is not defined. The carbon estimated may have been a harmless particle of soot, or in part it may have been essential to the spread of a deadly disease. Nevertheless, analyses are made as a matter of official routine by sanitary officers in England and France. The organic substances are absorbed by aspirating large volumes of the air through a small volume of distilled water, and the liquid menstruum is then investigated by the processes of water analysis. Professor Remsen, of the Johns Hopkins University, Baltimore, Md., endeavored to improve on this process by filtering the air through powdered and moistened pumice before passing it in fine bubbles through the distilled water. He thus showed that, so far as could be determined by chemical means, all nitrogenous matter was retained by the filter. But, as germs or microscopic organisms might have passed through without thus showing their presence in the absorbing liquid owing to the necessarily minute trace of nitrogen in them, the writer planned and carried out for the National Board of Health a series of experiments which determined, first, that the nitrogenous matter of air, excluding ammonia from consideration, is particulate; second, that it consists in large part of micro-organisms; and third, that filtration through Austrian glass-wool effects their removal from the passing air. The experiments were conducted in a sterilized apparatus. The air was drawn through a short glass tube one centimetre in diameter, lightly packed for two or three inches of its length with the glass wool. From this it was passed in fine division through pure distilled water. After this it was mixed with pure steam generated from a dilute solution of alkaline permanganate of potash, the mixture immediately entering the tube of a Liebig's condenser, where the steam was deposited, carrying down with it, after nature's process of air purification by the rainfall, any micro-organisms which might have escaped removal by filtration or absorption. The difficulties in the way of sterilizing the various parts of this apparatus were such that the first experiments, which gave speedy developments in culture-liquids tainted by the filter, the absorbing liquid, and the condensate, were regarded only as the practical expression of these difficulties. The experiments were repeated with precautions suggested as necessary by the previous experience, and ultimately success attended them. The culture-liquids, tainted with portions of the filter, became turbid in from two to nine days. Those impregnated with a portion of the water in the absorbing flask generally remained unchanged at the close of the experiments, three months and ten days after the date of the first one completed. Those tainted with the condensate became hazy usually a few days later than the liquids containing the filter taint; but in two instances there were no developments, and in two others the haziness did not occur until three and five weeks, respectively, had passed. In comparing the results of cultivation in the case of the filters with the stability of the culture-liquids in presence of the water from the absorbing flasks, it is evident that germs were removed by the glass-wool; but that this removal was not thorough is manifested by the fecundity of the condensate. Germs escaped the filter and passed through the distilled water in the air-bubbles, to be subsequently deposited with the vapor in the tube of the condenser. Ammonia, in like manner, in part escaped absorption, and was condensed. Nevertheless, the efficiency of the filtration must, in general terms be admitted, since, in certain instances, the condensate failed to induce change in the culture-liquid.

The mass of the matters collected respectively on the filter, in the absorber, and in the condenser were submitted to chemical examination, the result showing the absence of organic nitrogen on the distal side of the glass-wool.

One of the processes of water analysis to which these matters were subjected involved the distillation of the ammonia which was present in the liquid, and its estimation by the calorimetric method with Nessler's solution. Ammonia gives, with this test solution, a faint straw-yellow color, which deepens, in proportion to the amount of ammonia present, to a dark sherry-brown, or to a dark haziness or distinct precipitate. But it not unfrequently happened that in testing for ammonia in the distillate from the pure water in which the glass-wool containing the organic matter of the air was suspended, as well as in that from the absorbing liquid which contained most of the ammonia, and in that from the condensate which contained but a trace, a citron-green color was produced which marked the ammonia reaction and rendered its estimation impossible. Dr. Kidder, of the Navy, observed this interference with the ammonia coloration, and attributed it to the presence of substances evolved in the putrefaction of organic matter. He concluded from the few experiments he made that the amines are not neces-

sarily concerned in its production, as he found that butyric acid gave a somewhat similar interference to that met with in the experiments on air-washings. But the haziness with which the presence of butyric acid masks the true ammonia color is not the citron-green coloration which so frequently occurs in the analysis of foul airs. This is due to the presence of an ethyl compound which is given off from the carbohydrates while undergoing change. It may be obtained free from the ammonia which ordinarily accompanies it and obscures its reaction by submitting the liquid containing both to the process of nitrification. It may also be obtained from ammonia and free glucose, and from starch, cane-sugar, tannin, salicin, etc., after treatment with heat and acids. (See Water Analysis.)

In some of the experiments referred to, the air volume, 100 litres, was passed through the interior of a glass globe which contained liquid sewage and silt, garbage, or other foul and decomposing materials, and then through the glass-wool filter, absorber, and condenser to remove the matters with which it had become contaminated. Culture experiments showed the satisfactory removal by the filter of all germs and nitrogenous matters, ammonia excepted and. chemical tests determined approximately the quantity of organic matter thus removed. In some instances a second air-volume of 100 litres was drawn over the organic matter in the globe, and the results obtained from the filter through which it was afterward passed did not differ from those of the first experiment on the same organic matter. From these experiments the conclusion appears admissible that the volume of air which is contaminated by a certain decomposing organic mass is the volume which comes in contact with it. If no air is drawn through the foul globe, only that which is contained in it is rendered impure. This air has its oxygen in time replaced by the foul-smelling gases of decomposition. Evaporation takes place from the contained liquid until the stagnant and enclosed air becomes saturated. The ascensional force of the evaporation carries from the smeared and half-dried sides of the globe, and from the unsubmerged solids within it, some of the innumerable micro-organisms with which they are pervaded, and the air becomes charged with organic particles to an extent proportioned to its temperature and hygrometric condition. If a volume of air is drawn through the globe it will be contaminated by organic matters carried away by its own movement and by the increased activity of evaporation produced by it. If a second volume is drawn through, it will be contaminated in like manner, and to the same extent if the volume, rapidity of passage, temperature, and hygrometric condition are the same in both instances; and so for a third, a fourth, or more volumes, until the decomposing mass has become changed by their agency. This is recognized practically in sanitary work. The dead are buried that their decomposition may not contaminate the atmosphere. For the same reason garbage is collected and removed. A receptacle for foul-smelling and fermenting matters is less of a nuisance and less dangerous to health when fitted with an air-tight cover than when freely exposed to the air, for in the latter case every volume of air which comes in contact with it is a volume of air polluted. Sanitary officials in growing cities protest against the continued existence of small surface streams which of necessity pass into the condition of open sewers, tainting every volume of air which comes in contact with their foulness. These are bricked over and the air is preserved from the impure contact. But in the construction of regular systems of sewerage provision is made for this contact under the name of ventilation. The sewers are tapped at regular intervals along the streets for the exit of the contaminated air. From the present point of view this *ventilation of the sewers* is of questionable benefit. The volume of air rendered impure, and possibly dangerous, is proportioned to the thoroughness of the ventilation. Sulphuretted gases may be diluted, and the outflowing air be free from disagreeable odors, but the very air movement which effects this may raise invisible clouds of fermentative and morbific agencies from the foul interior. Experiments on this point would be of value. Those mentioned above seem to indicate that the communication with the outer air should only be such as is needful to relieve tension and prevent the forcing of seals, and that these air-holes should be guarded by some filtering material. But since the volume of air which becomes contaminated is that which comes in contact with the fermenting material, it may be reduced as well by diminishing the extent of the impure surface as by cutting off the ventilation. Hence sewers of small size, as in what is known as the separate system, are to be preferred, on sanitary grounds, to the large ramifying caverns of the combined system; while the Liernur system must be regarded from this point of view as the perfect method of sewage removal. The foul airs which arise from sewer apertures are matters of every-day observation. If well diluted with air they may not affect the sense of smell, but they rise, nevertheless, from the grated covers on our streets, and may be seen, by the vapor precipitated from them, as an uprising column in weather which clouds the air of respiration thrown out from the lungs. With open streets and lively breezes it is probable that these exhalations are dissipated, or rather diluted, to harmlessness, but in enclosed spaces and stagnant atmospheres the sewer-air, which is so carefully excluded from living-rooms by intelligent plumbing, may enter as fresh air through open windows and apertures specially devised for its admission.

The influence of these particulate organic matters of the air on the health of those exposed to them will be discussed under the caption Miasms.

Before leaving the consideration of air in its sanitary aspects, it is needful only to refer to the influence of certain *climatic factors*, which operate in a great measure through its medium. These are heat, moisture, and movement. The influence of varying barometric pressures usually finds an expression in the temperature. Heat is of importance in the generation and evolution of miasms; but aside from this the degree of temperature of the atmosphere is of importance to the animal economy, according as it does or does not necessitate an unusual activity of the vital energies, for the preservation of the animal heat. Moisture acts chiefly by interfering with the natural cooling process effected by evaporation from the skin. But the principal factor in the determination of climatic influences is the wind. The absolute temperature as recorded by the thermometer gives but imperfect information regarding climate, unless supplemented by a cotemporaneous report of the air movement, and unless the medical climatologist is able to appreciate and express in definite terms the change made by this movement in the value of the temperature. Zero Centigrade, with no wind blowing, is one set of climatic conditions; the same degree of absolute temperature, with a steady breeze of ten miles an hour, forms a wholly different climate. What is manifestly required is a thermometer which will enable us to say how cold it is to the feel, or, in other words, with what rapidity the animal heat is carried away under a given set of atmospheric conditions.

The amount of labor which has been expended in the routine work of keeping meteorological records in the past has been enormous. These have been compared with fragmentary records of sickness and mortality, and the concurrence of cold with certain diseases of the respiratory organs, and of heat with disorders of the digestive system, has been repeatedly presented, while lines have been drawn showing the fluctuations in the annual course of many diseases which are influenced directly or indirectly by temperature. Nothing more is to be expected from such work. If there were on the record as many and as continual observations on the temperature of the soil in miasmatic regions as there are of the air, our knowledge of the fermentative processes which are connected with the exhalation of disease-poisons, or with the manifestation of disease-causes, would be more advanced. There is a field for work in this direction, which sanitary observers might cultivate, since the Signal Service Bureau has relieved them from the labor of taking the meteorological notes.

Charles Smart.

AIR-PASSAGES, Foreign Bodies in.

Nose.—The presence of foreign bodies in the nose [1] is of common occurrence. The list [2] of them comprises extraneous substances introduced either through accident or design by infants or insane adults; sequestra of diseased bone; and parasites. The history is usually as follows: A child of about two, old enough to creep, but not sufficiently intelligent to know better, thrusts some small, rounded object, such as a bean or a shoe-button, which it has found upon the floor, into its nostril. If the child be not caught in the act the body may escape immediate detection. Soon symptoms of chronic inflammation are established. These are confined to the nostril in which the body is, and continue until it is removed, the irritation often being severe and the discharge exceedingly fetid. The mucous membrane adjacent to the foreign body is in a condition of superficial erosion. The body, if too firmly impacted to be dislodged by simply blowing the nose, remains fixed, usually in the inferior meatus, until removed by the surgeon. Removal should be attempted by means of a hooked probe or fine forceps. The sensitiveness of the nasal cavity should be borne in mind, and if, after two or three gentle and carefully directed efforts success be not attained, an anæsthetic (chloroform to a healthy child under six) should be given, and the removal of the body carefully accomplished. Copious hæmorrhage, lasting two or three minutes, often follows, but is generally of little moment. The nostril should be washed several times a day with a weak disinfectant, preferably a solution of potass. permanganate. In four or five days the membrane will often have healed so completely that no trace of trouble can be seen; the discharge ceases entirely, and cure is complete. The possibility of the presence of a foreign body in all cases of fetid discharge confined to one nostril should always be remembered, and the nostril having been cleansed with a warm douche, examination should be made with probe and speculum. In simple cases a gentle stream of salt warm water carried through the free nostril and out of the other, or a sternutatory, will sometimes succeed. If the object be lodged far backward care should be taken in removing it not to allow it to fall into the larynx. Rhinoliths [3] are merely calculi formed by an accumulation of the earthy salts of the nasal secretions around some foreign body or inspissated mucus. Their presence has given rise to such irritation that they have been mistaken for cancer. Careful examination and the history of the case will easily establish the diagnosis. If they are too large to be readily removed they should first be crushed by a lithotrite of proper size. Sequestra of bone, particularly in tertiary syphilis, sometimes remain in the nasal cavity after their separation, thus acting as foreign bodies. They must be thoroughly removed preliminary to further local treatment.

Parasites.—In tropical countries, seldom elsewhere, various kinds of flies, of the order *muscidæ*, may enter the nasal cavity, preferably of a patient suffering from catarrh, and there deposit their eggs.[4] These are quickly hatched, causing in succession irritability, tickling, and sneezing; later, formication, bloody discharges, and epistaxis, with œdema of the face, eyelids, and palate; excruciating pain, generally frontal, insomnia, and if the condition be unrelieved, convulsions, coma, and death. Sometimes the larvæ are sneezed out, or may be seen on examination of the parts. This will, of course, establish the diagnosis. Destruction caused by the larvæ may extend to the mucous membrane, the cartilages, and even the bones of the head; the ethmoid, sphenoid, and palate bones having been found carious. Where the maggots have entered the frontal sinus, or the antrum of Highmore, injections of tobacco or alum, or insufflations of calomel, formerly used, will be of little use. *Chloroform* or ether,[5] preferably the former, either inhaled or driven into the nasal recesses in the form of spray, is the sovereign remedy, as under it the larvæ are not killed, to remain *in situ* and thus cause further trouble, but escape with all haste to the outer air. Meanwhile, opium should be given to allay pain, and the patient's strength carefully sustained.

Leeches, ascarides, earwigs, and centipedes [6] have been found in the nose, causing insomnia, frontal pain, sanious discharge from the nose, lachrymation, vomiting, and, in some cases, great cerebral excitement. Sternutatories are generally sufficient for their expulsion. It may be necessary, however, to trephine the mastoid.

Tonsils.—Three general varieties of foreign bodies may be found in the tonsil: 1, Foreign bodies proper, or substances which have become lodged in the tonsil during deglutition; 2, tonsillary concretions or calculi; 3, parasites. The last two conditions are not common; the first will be described under Foreign Bodies in the Pharynx.

Tonsillary calculi are formed in the lacunæ of a chronically inflamed tonsil by a perverted condition of the natural secretions, and their retention in the lacuna by closure of its outlet. They vary in size, seldom attaining a greater diameter than three-fourths of an inch, and consist of phosphate and carbonate of lime, some iron, soda, and potassa, with varying proportions of mucus and water. Hence, they are not necessarily of gouty origin. The *symptoms*, generally not prominent, may be slight pricking of the throat with, occasionally, dysphagia. The presence of the calculus is sometimes directly irritating, and may give rise to quinsy, ulceration of the cavity, and abscess.

Diagnosis, by ocular examination or the use of the probe, is usually easy, as is the removal of the calculus by means of a forceps. Sometimes, however, the mass is so completely covered that it is only seen upon removal of the tonsil. In most cases the latter operation will afford the most certain cure. Very rarely hydatids and trichocephali have been found in the tonsil.

Pharynx.—The frequency with which foreign bodies are arrested in the pharynx, and their variety, are very great. Certain individuals seem especially liable to this accident, either from carelessness in eating, insensibility of the parts, or from some unusual irregularity in the pharyngeal walls. Foreign bodies of large size generally lodge in the lower part of the cavity, where the cricoid and arytenoid cartilages project backward, or between the base of the tongue and the epiglottis. Small and sharp-pointed bodies may become fixed at any part of the pharynx, particularly in the tonsils, on account of their exposed portion and the irregularity of their surface. They may also be entangled in the pillars of the velum, or in the lateral folds of the cavity. A large body may be found stretching across the whole width of the pharynx.

Symptoms.—Local pain, dysphagia, occasionally inflammation with ulceration or abscess of the pharynx, but generally localized inflammation and irritation. If an abscess be formed, the body may escape through a fistulous opening in the neck, or it may perforate some important blood-vessel, or even penetrate the intervertebral substance and cause caries of the vertebral bodies.

Inflammation of the pharynx may give rise to dyspnœa, while a large foreign body may cause suffocation by obstructing the entrance to the larynx.

The *diagnosis* can generally be established by the history of the case, and by inspection of the pharynx. Nervous patients often insist upon the presence of a foreign body in the throat, despite all assurance to the contrary, particularly if the pharynx be sensitive, or, as often happens when a hard substance may have caused a slight laceration of the mucous membrane while being swallowed.

Treatment.—The patient's tongue should be well depressed, and the upper parts of the pharynx carefully examined in a strong light. If the foreign body does not then appear, search should be made for it in the region of the base of the tongue, the glosso-epiglottic sinuses, and the upper portion of the larynx, with the tip of the finger, or, better still, by the aid of the laryngoscope. If present, it will generally be found without much difficulty, and should be removed by the finger or by a suitable forceps or probang. If dyspnœa be urgent, immediate surgical interference, of a nature suited to the special features of the case, either tracheotomy, thyrotomy, or, if possible, some form of sub-hyoidean pharyngotomy, may be required. The sensations of the patient are often unreliable, and

the sense of irritation caused by the presence of the body may continue for a long while after its removal. This is relieved by swallowing small lumps of ice, and later, if necessary, by the application of astringents and galvanism.

LARYNX.—By reason of the danger to life which attends the lodgment of a foreign body in the larynx, this condition becomes one of the most important in surgery. The variety of objects found is infinite, and may be thus divided: Alimentary matters, introduced during mastication, in the act of laughing or talking, in deglutition, or in inspiration during vomiting; metallic bodies, such as coins, buttons, puff-darts,[7] etc.; teeth, artificial or natural, necrosed bone[8] from neighboring regions, as from the nose in tertiary syphilis, and fragments of the laryngeal cartilages themselves, as thrown off in the late stages of syphilis, tuberculosis, and cancer of the larynx. Foreign bodies in the trachea may pass upward and become impacted in the larynx; and, rarely, they may gain access to the larynx directly from without, by forcible penetration of its walls, as in the case of bullets.[9] Again, the epiglottis may become incarcerated in the larynx,[10] or occlusion take place from the so-called swallowing of the tongue.[11] The *symptoms* vary with the size and position of the object. Thus a large body fixed in the rima glottidis may, unless dislodged, cause almost instant death. Again, small bodies lodged in out-of-the-way corners may remain indefinitely, causing nothing more than cough and discomfort. Dyspnœa may occur days after the reception of a foreign body, from inflammation and tumefaction of the soft parts of the larynx, and danger from the presence of a foreign body may suddenly become imminent from alteration in the position of the body. Great peril sometimes arises from violent spasm of the glottis, due to irritation caused by the foreign body. Mental anxiety and localized pain are prominent symptoms in cases in which the accident does not immediately threaten life, while active inflammation is speedily set up. A cautious *prognosis* must be given, even after removal of the body, as long as there are any symptoms of local inflammation. The *diagnosis* is established by the history of the case, verified or otherwise by laryngoscopic examination. The greatest difficulties arise with children too young to express themselves, in whom pain in the throat, and symptoms resembling croup, will often be the only indications obtainable. Here the laryngoscope will be indispensable.

Treatment.—The offending body should, of course, be at once removed; if possible, through the natural passages and by means of the laryngeal forceps, aided by the laryngoscope, in case the symptoms are not urgent. If asphyxia threaten, tracheotomy should be done at once, and the foreign body afterward extracted as described above. Bodies at first immovable may sometimes be loosened by reducing the local inflammation. In rare cases, where the object has become firmly impacted, thyrotomy may become necessary. A case is recorded in which a needle, transfixed in the larynx, was pushed through the anterior laryngeal wall, and thus removed.[12]

TRACHEA AND BRONCHI.—Any body which can pass through the rima glottidis may, of course, find its way into the trachea under the same circumstances described under the head of Foreign Bodies in the Larynx. Sharp objects lodged in the œsophagus, and even diseased bronchial glands, may work their way through the walls of the trachea, and into its cavity. Parts of instruments used in intra-laryngeal operations, and of tracheal canulæ,[13] laryngeal brushes, and even bits of solid nitrate of silver, occasionally, through accident or carelessness, drop into it. If too large to enter either main bronchus, the body will probably remain at the bifurcation. Otherwise it will pass into one bronchus or the other, preferably the right, on account of its anatomical position, in the proportion of five to three, and thence travel indefinitely into one of the more remote bronchial divisions.

The *symptoms* will depend upon the nature of the body and its exact situation in the lung. Small objects have remained encapsulated with mucus for years without causing discomfort or serious results. Smooth, rounded bodies irritate less than irregular ones. Inflammation of the lungs from a foreign body may occur, the presence of the body being unknown. Large objects and fluids may cause death by instant suffocation, or death may result in the course of a few minutes, the symptoms presented being urgent dyspnœa, frantic efforts at relief on the part of the patient by thrusting the finger down the throat, rushing to the window for fresh air, and making great inspiratory efforts, while cyanosis quickly follows, and if aid be not speedily afforded, death, with all the signs of asphyxia. Severe dyspnœa, followed by relief without extrusion of the foreign body, indicates that the body has probably dropped from the larynx into the trachea. Dyspnœa is, of course, more urgent when the trachea is occluded than when the foreign body only stops one bronchus. The body may change its position, passing from one bronchus to that of the opposite side. A body, small when swallowed, may become more dangerous through increase in size, either by swelling from imbibition of water, or by forming the nucleus of a concretion. Physical signs from the presence of a foreign body in the lung may be altogether wanting, but are generally more or less distinct, the symptoms being whistling or flapping sounds at the point of lodgment, pain, and decreased fremitus, with absence of respiratory murmur in the lung beyond. Diagnosis is often very difficult. At or about the bifurcation the body may be seen with the laryngoscope. The lodgment of a foreign body in the lung may result in pneumonia, tuberculosis, abscess, or gangrene. Or, it may become encapsulated and do no apparent harm. Rarely a body, generally an ear of barley or other grain, having formed an abscess of the lung, has been discharged through the wall of the thorax, with complete recovery.[14]

Diagnosis.—The fact that some foreign body has been inhaled should be established if possible, and the site of the body determined. In children and incompetents, and in cases where the dyspnœa is urgent this may not be easy. The laryngoscope is useful in excluding the presence of the body from the larynx, even if it be not visible in the trachea. The *prognosis* is serious, depending upon the nature of the body, the amount of dyspnœa, and the organic lesions which may result. The period of greatest danger is at the first, and although this diminishes in varying degree as time passes, it is never entirely absent. Even after expulsion death may occur from the organic disease set up. The expulsion of one object does not, especially with children, preclude the possibility of others remaining in the lung.

Treatment.—Since the publication of Professor Gross's admirable article the necessity for operation in cases of foreign body in the trachea has been an accepted law. Recently Weist has ably shown that the conclusions arrived at by Gross and Durham are, to some extent, misleading. His conclusions are based upon 937 cases of foreign body in the air-passages; of these, 599 were not subjected to bronchotomy; 460 recovered, or 76.79 per cent.; 139 died, or 23.20 per cent. Bronchotomy was performed in 338 cases, with 245 recoveries, or 72.48 per cent.; 93 died, or 27.42 per cent.; a difference in favor of non-interference of 4.31 per cent. Comparing the statistics with those of Gross and Durham, the former shows, in cases without operation, 11.03 per cent. more recoveries than those of Gross, and 19.29 per cent. more than those of Durham, and 7.24 per cent. more than the aggregate of the cases of both Gross and Durham. In cases operated on, Weist shows 12.21 per cent. less recoveries than Gross, 1.40 less than Durham, and 4.29 less than the cases of both combined. Of the whole number of cases studied, 1,674, there was one death in 3.5 cases without operation, and one death in 4 with operation. Bronchotomy, therefore, has not shown such good results over non-interference as to justify unvarying recourse to it, so that the policy of awaiting spontaneous expulsion is often justified. Since certain classes of foreign body, such as watermelon seed, corn, coffee bean, etc., are much more easily expelled from the air-passages than others, the nature of the substance, aside from other indications, must influence the decision as to the propriety of immediate interference.

The conditions demanding speedy operation are: 1. Ur-

gent and dangerous symptoms, as progressive dyspnœa, or frequently occurring attacks of dyspnœa, or laryngeal spasm, when laryngoscopic examination fails to find the object or shows that its speedy removal by the natural passages is impossible. 2. Where a sharp and irregular body is impacted, as shown by the laryngoscope, in such a way that immediate extraction is impossible, and where acute inflammation, and especially œdema, are rapidly occurring, as evinced by increasing dyspnœa. 3. In the case of a foreign body of any nature, loose in the trachea, movements of which excite laryngeal spasm or cough of dangerous violence. 4. In case of a foreign body impacted in either of the primary bronchi, as ascertained by the rational and physical signs, particularly by auscultation. Here low tracheotomy and immediate direct attempts at extraction are often successful. Direct examination of the site, and demonstration of the foreign body in or at the mouth of a bronchus, by means of the finger introduced quickly into the trachea, are possible, and this knowledge renders the subsequent instrumental removal of the body more easy. 5. Sharp-pointed, hard, and irregular bodies within the air-passages will, as a rule, demand bronchotomy, provided they are not so located that they may be reached and removed by the natural passages at an early moment. The plan of treatment by inversion of the patient has of late years fallen into disrepute, and should seldom be practised, unless tracheotomy can be done at once if required. In employing it, it should be remembered that the supine position will favor exit of the body, particularly if the glottis be in the condition of deep inspiration. In all cases the diagnostic importance of a thorough laryngoscopic examination cannot be too strongly insisted upon, nor the great utility of the laryngoscope be overestimated.

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AIX-LES-BAINS (a station on the railroad which runs from Lyons to Turin) is a small town in the Arrondissement of Chambéry, in Savoy. It is charmingly situated on the brow of a hill, in close proximity to lofty limestone mountains (the Beauges), a spur of the Savoy Alps, and not far from the eastern shore of the Lake of Bourget. Its elevation above the sea-level is about 900 feet, and above the lake about 100 feet. Climate mild; air and ordinary drinking-water both pure. Hence crétins and those affected with goître are rarely seen here. There are two thermal sources which, in chemical composition and in the temperature of the water, differ only very slightly from each other. These are the Source de Soufre and the Source d'Alun. According to Bonjean, the temperature of the sulphur spring is 45° C. (113° F.), and it contains in 1,000 parts:

Sodium sulphate	0.0960
Magnesium sulphate	0.0352
Calcium sulphate	0.0160
Aluminium sulphate	0.0548
Sodium chloride	0.0079
Magnesium chloride	0.0172
Calcium fluoride, Calcium and aluminium phosphate,	0.0024
Potassium iodide	Traces.
Calcium carbonate	0.1485
Magnesium carbonate	0.0258
Ferrum carbonate	0.0088
Silicon hydrate	0.0050
Organic matter	Traces.
Total of fixed elements	0.4176

The unstable elements in 1,000 cubic centimetres of the water are represented as follows:

Hydrogen sulphide	27.24 c.c.
Carbon dioxide	13.07 c.c.
Nitrogen	25.46 c.c.

The alum spring has a temperature of 46.5° C. (115.8° F.), and its chemical composition is but little different from that of the sulphur spring.

However, it is not so much to the chemical composition of its waters that the hot springs of Aix owe their great celebrity, as it is to the systematic manner in which these waters are used. Durand-Fardel speaks of the establishment of baths in Aix as pursuing a genuine system of thermal hydrotherapeutics. In this respect it may be compared with Aachen and Luchon.

The principal form of bath employed is the douche, which is administered in a variety of ways, and usually in connection with massage and frictions. After the application of the douche, the patient takes a warm bath in the so-called "Bouillon," in which the water is kept in constant motion.

The energetic and exciting methods employed at these baths render them especially efficacious in cases of rheumatic or gouty exudations, in scrofulous swellings of the periosteum, or of the parts surrounding the joints, etc. They have also proved useful in cases of muscular atrophy, caries, contractures, etc.; in chronic affections of the skin, and in syphilis; in affections of the larynx and pharynx; in chronic bronchial catarrh; and, finally, in quite recent times, in uterine affections. (Eulenburg.)

Henry Fleischner.

ALAP, a Hungarian village with railway connections, is divided into upper and lower Alap, each of which contains a remarkable spring of pure and very strong bitter-water; in fact that of lower Alap is one of the strongest natural bitter-waters known. The waters of lower Alap are also used for bathing. In 1,000 parts, by weight, there are:

	Upper Alap.	Lower Alap.
Magnesium sulphate	3.136 parts.	4.094 parts.
Sodium sulphate	5.711 "	18.149 "
Calcium sulphate	1.828 "	0.260 "
Sodium chloride	4.186 "	14.486 "
Total solids	16.549 parts.	37.625 parts.

H. F.

ALBANY ARTESIAN WELL. *Location*, Ferry Street, Albany, N. Y.

ANALYSIS.—One pint contains:

	Grains.
Carbonate of soda	5.00
Carbonate of magnesia	2.00
Carbonate of lime	4.00
Carbonate of iron	1.00
Chloride of sodium	63.00
	75.00

Carbonic acid gas, 28 cubic inches.

The well is 500 feet deep, and has a temperature of about 52° F. This is a saline-chalybeate water, very similar to the Congress, High Rock, etc., of Saratoga, and, undoubtedly, has the same general source as those springs.

G. B. F.

ALBINISM. The condition which has been termed albinism consists in a congenital absence of the normal pigment. There are two varieties, the universal and the partial. The first of these is that which is best known. The skin is perfectly pigmentless and white, excepting where the blood-vessels coursing beneath it give it a rose tint. The general condition of the skin is normal, otherwise than as regards the absence of pigment. The hair is white or flaxen in color (in one case reported it was red), of a fine texture, and peculiarly silky sheen. The eye partakes of the anomaly; the iris is colorless, so that its blood-vessels give it a red hue, excepting in some cases, when viewed obliquely, the interference of light-rays give it a blue color. As a result of the want of pigment in the iris, albinos suffer from photophobia and nystagmus, and are seen constantly blinking the eyelids and rolling the eyes involuntarily from side to side. They see best in the twilight.

Albinos are usually of weak constitution, and are apt to be intellectually deficient. Exceptions are known, however, to both of these conditions, and one of the best papers extant on albinism, so it is said, was written by a German albino named Sachs.

The only etiological element known or suspected in the production of albinism is heredity, and even this is wanting in the greater number of cases. It seems probable that the sisters in any given family are likely to be attacked rather than the brothers, if more than one individual is affected.

Partial albinism is ordinarily met with in the colored race, the so-called "piebald negroes," and its existence in the white races has been denied. Lesser, however, has recently described a case, and it is believed that instances of congenital partial loss of pigment are not excessively uncommon among the lighter colored races, but that cases have escaped attention. Partial albinism over limited areas has been shown in one case at least by Lesser to follow the course of the cutaneous nerve-distribution, as is the case with the pigmented skin in the so-called "nerve nævus." One peculiarity of the pigmentless patches in this form of albinism is that the decolorized skin fades gradually into the surrounding integument, whereas in vitiligo the skin immediately surrounding the white patches is more deeply pigmented, giving a sharply defined boundary line. The hair growing over the pigmentless patches in partial albinism is white, although it is a curious fact that in the similar decolorization of the hair, apparently due to the same causes, called sometimes poliosis (see Calvities) the skin underneath may be of normal color.

Arthur Van Harlingen.

ALBUMINOID DEGENERATION, the term used by the English to denote what is ordinarily called amyloid degeneration, it being supposed that the amyloid material represented a modified form of albumen, an acid albumen. This has been shown to be wrong. See Amyloid Degeneration. *W. W. Gannett.*

AJACCIO. The town of Ajaccio is situated at the head of a beautiful bay, bearing the same name, which indents the western coast of the island of Corsica. At its mouth (the broadest part) the width of this bay is about ten miles from cape to cape, and it extends inland in a northeasterly direction for about the same distance, having in its general outlines the shape of a letter **U** or of a blunt-pointed **V**. At a distance of some twenty miles from the shores of the bay stand the lofty mountains (six thousand to nine thousand feet high) constituting the backbone of the island, while the outlying spurs of these mountains come down to the sea in such a manner as to afford to the town of Ajaccio an all but complete protection from northwesterly, northerly, and easterly winds, leaving it exposed to the warmer winds blowing from the south and from the southwest. From this account of its situation it would naturally be inferred that the climate of Ajaccio should be a warm one, and, as will presently appear from the statistics of temperature about to be quoted, this inference is entirely correct. In this feature of exposure to the south and shelter on the north, the town greatly resembles many of the celebrated winter resorts of the Italian Riviera, while its somewhat lower latitude should insure its being even warmer than these. Accordingly, it is no surprise to learn that the mean winter temperature of Ajaccio is more than 2.7° F. (1.5° C.) higher than that of the Riviera. The writer of the article on Ajaccio in "Eulenburg's Real Encyclopädie," from whose contribution the preceding statement is taken, mentions further that there is less variation in the mean temperature from month to month of the winter season at Ajaccio than is to be found at places lying along the Riviera. The relative humidity of Ajaccio is given by the same writer as varying between seventy and seventy-eight per cent. The average total number of rainy days occurring during the months of October, November, December, January, February, March, and April, he states to be from forty to forty-five. The annual rainfall, according to Doctor Hermann Weber in "Ziemssen's Handbuch der Allgemeinen Therapie," is 24.8 inches (630 mm.). Dr. Lombard states (*Traité de Climatologie Médicale*, t. iv., p. 620) that the average number of perfectly cloudless days at Ajaccio is 136; of partly cloudy days, 89; and of days on which the sky is completely obscured by clouds, 51. He further remarks that the greatest proportion of cloudy days occurs during the spring months, only 43 cloudless days being observed at that season, on the average, against 49 cloudy ones. The mean temperature at Ajaccio for the year, for each of the four seasons, and for eight out of the twelve months of the year is shown in the following table:

	July.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	Summer.	Autumn.	Winter.	Spring.	Year.
E.......	..	68.18	58 82	53.78	50.36	54.14	56.48	59.36	..	..	..	..	..
Z.......	..	..	..	..	..	..	..	..	76.78	66.68	52.16	60,26	62.60
H.......	78.08	66.92	..	..	50.30	..	..	58.28	..	..	..	..	63.68

E., Eulenburg's Real Encyclopädie; Z., Ziemssen's Handbuch der Allgemeinen Therapie (Weber); H., Hann's Handbuch der Klimatologie.

The daily variation of temperature is never great, not more than 9° or 10.8° F., even in November and December; the evenings are extremely mild, not colder than 50° F. even in February ("Eulenburg's Handbuch").

On the authority of the Drs. Versini, father and son, the climate of Ajaccio is said by Dr. James Henry Bennet to be a healthy one, and no epidemic disease prevails there, save only malarial fever of a mild type, which visits the town only during the latter part of summer and in the early autumn, its attacks occurring chiefly when the wind blows across from the east shore of the bay, where the Gravone and Prunelli rivers empty into the sea. On the other hand, the writer in "Eulenburg's Handbuch" remarks that the health of the resident population at Ajaccio is not especially good, which circumstance he is disposed to attribute to the imperfect hygienic conditions prevailing in the town itself. The soil at Ajaccio is granite, and the surface-water drains rapidly away. The air is free from dust at all seasons. "The vegetation of Ajaccio and the neighborhood indicates a climate at least as warm as that of Cannes and Nice, perhaps even a shade warmer; the olive, the orange, the prickly pear thrive with great luxuriance. . . . The lemon-tree grows also, and bears fruit out of doors, but only, as at Nice, in very sheltered and very protected spots. . . . The botanical productions of Corsica assimilate, as might be presumed, to those of the countries that surround it. The north by its vegetation approximates to the Riviera, the east to the Italian coast, the west to Provence and Spain, while the south, and I may say the entire island, shows decided African affinities" (Dr. J. H. Bennet in "Winter and Spring on the Shores of the Mediterranean").

So far as its climate is concerned, the town of Ajaccio presents, in the estimation of the writer in "Eulenburg's Encyclopædia," greater advantages than any point in Italy as a place of resort for persons suffering from any form of pulmonary or cardiac disease, or from scrofula,

as well as for invalids merely seeking a quiet and suitable place of rest. He specifies the three months of February, March, and April as those which it is most desirable for the invalid to select for his sojourn at Ajaccio. The Cours Grandval is generally chosen by foreigners for residence, lying as it does in the northwestern portion of the town, which is the section most protected and best sheltered from the winds. Although it is now no less than twenty-three years since Dr. Bennet first pointed out, in 1862, "that the exceptionally sheltered situation of Ajaccio, on the western coast, renders it a suitable residence for invalids requiring a moister climate than that of the Genoese Riviera," and that it appeared to him "thoroughly eligible as a winter residence," it is somewhat disappointing to learn from the fifth edition of his own book (1875), and from the above-cited work of Eulenburg, that, despite certain improvements in this direction, the character of the hotel accommodation and the facilities for social life existing in the town still leave something to be desired before the place can become as popular a resort for invalids as it is justly entitled to be. Up to 1880 good accommodations were only to be found at certain of the hotels and in villas (Eulenburg). "Biermann," says Dr. Weber in "Ziemssen's Handbuch," "speaks favorably of the climate; H. Bennet and Rohden, who also know the place from personal experience, have high hopes of its future, when the accommodations and the means of communication with the continent shall have been still further improved. My own experience in four cases of pulmonary phthisis affecting the apex of one lung, and in two cases of chronic emphysematous catarrh is favorable; in one case of chronic pneumonia of the right lower lobe, and in two of asthma, unfavorable." Dr. Pietra Santa (quoted by Lombard) describes the climate of Ajaccio as both tonic and soothing in its effect, and as being well suited to cases of scrofula, to chlorotic and anæmic persons, and especially to those suffering from certain forms of pulmonary phthisis ("surtout aux phthisiques chez qui prédomine le lymphatisme et la forme torpide; il exerce également une influence prophylactique pour ceux qui sont prédisposés à la tuberculose").

"One of the objects of my visit," says Dr. Bennet, speaking of his exploratory trip to Corsica in the year 1862, "was to find a perfectly cool summer station for the English consumptive invalids who wish to pass the summer abroad. I found stations such as Arezza and the baths of Guagno, near Ajaccio, which would do very well for healthy persons anxious to escape from the extreme heat of Southern Europe during the summer months, but these localities are not sufficiently high and cool to be chosen as summer retreats by invalids. . . . On crossing the granite chain on the way from Corte to Ajaccio we came to a spot between Vivario and Bocognano, called Foci, the most elevated that is passed, which would no doubt do admirably for such a summer sanitarium. We were quite four thousand feet high. . . . The air was cool and pleasant, the sky clear, the mountains very beautiful; but there was only a small, dirty roadside inn." Malarial fever does not prevail in Corsica, even in the summer and early autumn seasons, according to Dr. Bennet, at any place having an altitude above sea level of five hundred feet.

It is disappointing, after considering the evident desirability of the establishment of such a mountain summer resort and its entire feasibility, to judge from the above quoted remarks of Dr. Bennet, to read, as we do in Dr. Hermann Weber's contribution to Ziemssen's work (1880) that "the mountains of the island have not yet been made use of for the establishment of satisfactory places of summer resort." "In the great primeval forests (of Corsica) are to be found wild boars and small game in abundance. In the higher mountains the native race of wild sheep, called mouflons, are met with. Their presence in the mountains is a strong attraction to enthusiastic sportsmen. In the alluvial plains on the eastern coast game abounds, and in the autumn and winter all kinds of water-fowl are met with in profusion. In the early autumn season, however, these districts are so very unhealthy that the pursuit of the game would probably be followed by severe fever" (Bennet, op. cit.).

Thanks to the good work done in Corsica by the French Government, excellent roads now intersect all parts of the island in every direction, and the entire suppression of the "vendetta" has rendered every portion of the island a perfectly safe residence for foreigners.

For the latest information concerning hotels, etc., and concerning the various lines of steamers which bind Corsica to the continent of Europe, the reader is referred to the tourists' guide-books of Murray and Baedecker. A great deal of useful and entertaining information respecting the scenery, history, climate, etc., of Corsica may be found in the pages of the delightfully written work of Dr. Bennet, from which such frequent quotations have been made in the penning of this article. (See also Gregorovius's "Wanderings in Corsica, its History and its Heroes;" "Notes on the Island of Corsica," by Miss T. Campbell; and several other similar works, all of which are recommended to his readers by Dr. Bennet.)

Huntington Richards.

ALBURG SPRINGS. *Location and Post-office,* Alburg Springs, Grand Isle County, Vt.

ACCESS.—By Central Vermont Railroad to Alburg Springs Station.

ANALYSIS (C. T. Jackson).—One pint contains:

	Grains.
Chloride of sodium	1.095
Chloride of magnesium	0.627
Chloride of calcium and carbonate of lime	0.601
Sulphide of potassium and sulphate of potassa	1.287
Sulphate of soda	0.887
Insoluble matters	0.100
Organic acid of the soil (crenic acid) and loss	0.250
Total	4.797

Sulphuretted hydrogen, a large proportion.

These springs are situated in the extreme northwestern part of Vermont, on Missisquoi Bay, an arm of Lake Champlain. The scenery round about is beautiful, embracing lake and mountain views. The climate is salubrious. (Walton.)

G. B. F.

ALCOHOL. The term alcohol (Syn.: ethyl hydrate, spiritus vini), once used to signify ethyl hydrate, is now generally applied, as a generic term, to a series of organic compounds, having in common certain chemical characteristics, the representative of which class is ordinary alcohol. It is produced by (1) the fermentation of all saccharine bodies, (2) by synthesis in the laboratory. In composition it is a hydrate, *i.e.*, the combination of a basylous radical with HO, and possesses the chemical properties of other hydrates, in forming salts with acids, etc.

PREPARATION.—Alcohol is produced by a particular ferment (torula cerevisiæ) acting upon saccharine substances; causing them to split up into alcohol and carbon dioxide, viz.:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} = \underset{\text{Alcohol}}{2C_2H_5HO} + \underset{\text{Carbon dioxide.}}{2CO_2}.$$

Cane-sugar and milk-sugar undergo a conversion first into glucose and then into alcohol. Minute quantities of acetic and succinic acids, also traces of aldehyde, fusel oil (amyl alcohol), and glycerine are produced at the same time. It is an interesting and important fact that the fermentation gradually ceases as the alcohol produced nears eighteen per cent. strength, and when the latter is reached, further action ceases. In the grape-juice, when this strength is reached, if there still be unfermented sugar, a "sweet" wine results; if none, a "dry" wine. This is due to the action, on the ferment, of the alcohol itself; the strength named above being just able to precipitate it. Pure wines, therefore, in moderate quantity will not precipitate the pepsine of the gastric juice, because not strong enough to do so immediately on taking, and in the stomach they are quickly diluted. In a diluted condition, under the influence of another ferment, alcohol is changed

to acetic acid, by a process of oxidation; thus, *e.g.*, white wine vinegar is produced.

$$\begin{array}{ccccc} \text{Alcohol} & & = & \text{Acetic acid} & + \text{ Water.} \\ C_2H_6HO + O_2 & & = & C_2H_4O_2 & + \; H_2O. \end{array}$$

When any of the fermented liquors are distilled, alcohol mixed with water passes over into the receiver. Repeated distillations free it from the greater proportion of higher alcohols and water. Its degree of concentration can then be determined by taking its specific gravity and comparing the result with a fixed table in which the strength for each specific gravity is worked out. The last amounts of water can only be gotten rid of with the greatest difficulty; as, for example, by distillation over quicklime out of contact with air (from which it rapidly abstracts moisture).

PHYSICAL PROPERTIES.—Absolutely pure alcohol is a colorless, limpid, pleasantly-smelling liquid having a sharp, burning taste; boiling at 78.5° C. (173.3° F.), and, at 20° C., having a specific gravity of 0.7895. Its affinity for water is intense, even abstracting it from the air when the bottle is not securely corked. If it be mixed directly with water, heat will be produced, the volume of the mixture being less than the sum of the volumes of the components, thus showing that combination has resulted. It is a solvent of great power, advantage of which is taken both in the arts and in medicine, *e.g.*, in the solutions of the *fixed* active principles of drugs called tinctures, or the solutions of the *volatile* active principles called spirits. It dissolves the alkaloids, essential oils, many resins, some fats, and CO_2 freely.

CHEMICAL PROPERTIES.—Alcohol occurs in commerce and pharmacy in varying degrees of concentration. When absolute alcohol is required, it should be freshly prepared, that of the shops being often only ninety-eight per cent. strong. Alcohol (U.S. Ph.) has a specific gravity of 0.82, and contains ninety-four per cent. by volume. Alcohol dilutum (U.S. Ph.) contains fifty-three per cent. by volume, and is the ordinary proof spirit. Its distinguishing chemical properties are: (1) its affinity for water; (2) its coagulating power on albuminoids, and (3) its antifermentative power when stronger than eighteen per cent. Advantage is taken of the first, in the mounting of microscopical sections, to abstract all the water before immersing them in the oils and balsams; of the second, in the hardening of the tissues for study and section; of the last, in the preservation in bulk of anatomical specimens, and those medicinal agents which undergo change in other media. Pure alcohol, properly diluted, will be understood to have been given, when we speak of its

PHYSIOLOGICAL ACTION.—*Locally:* Prolonged contact with the integument produces a sensation of heat which, if continued, results in inflammation. It hardens the same by coagulation of its albuminoid constituents and abstraction of water, the rapidity, to a certain extent, depending upon its concentration. Hence, it is useful in a relaxed condition of the skin, in sweating, and in ulcers; it acts here as an astringent, preventing the escape of leucocytes, and promoting the healing process.

Stomach and Intestinal Tract.—The action of this agent upon the stomach and intestinal tract has been one of the bones of contention between the advocates of teetotalism and those who, knowing its virtues, can utilize them. To incorporate the arguments of both sides would be foreign to the scope of this article which is to give the present status of scientific opinion. Small quantities of alcohol, properly diluted, taken into the stomach, produce an agreeable sensation of warmth which soon diffuses itself over the entire body. It is quickly absorbed. A turgescence of the capillary plexus of the mucous membrane occurs, which is speedily followed by a free secretion from the gastric follicles, due, in all probability, to (α) the increased supply of blood, and (β) the stimulation of their glandular orifices. Here, just as in any other organ of the body, long-continued or excessive stimulation will give rise to a pathological secretion, and a gastric catarrh will result. Larger quantities of alcohol interfere with the digestive processes, partly by rendering the albuminoids less soluble, partly by producing a secondary constriction of the stomach capillaries, and thus a diminished secretion. Experimentally applied to the mucous membrane of the dog's stomach (through gastric fistulæ), increased secretion and peristalsis of that viscus are observed. This is probably true in man. Even a few drops of the stronger alcohol, applied to the base of the tongue, has been seen to cause an almost immediate flow of gastric juice.

Poisoning by concentrated alcohol excites a burning sensation in the mouth, œsophagus, and stomach, soon followed by a gastro-enteritis, with its attendant symptoms of epigastric pain, fever, vomiting, and purging (sometimes of blood). *Post-mortem* appearances of the tissues in contact with which the concentrated alcohol has lain, are such as are naturally to be expected from its chemical properties, *i.e.*, abstraction of the watery constituents of the epithelial lining, cell-shrinkage, coagulation of the blood in the vessels of the mucosa, and hæmorrhagic softening.

The circulatory system, like the other portions of the organism, is affected by alcohol, but not in so marked a degree. In small quantities, its first effect is to stimulate the heart, causing a slight increase in frequency and a marked increase in force, accompanying which is a dilatation of the cutaneous capillaries, and probably also those of the brain. The intravascular pressure is increased. These phenomena are plainly visible in the flushed face, glistening eye, and animated expression of the person in the early stage of alcoholic influence. In poisonous doses, a lessening of the heart's power by one-twentieth and the blood-pressure by one-sixth occurs. Nothnagel explains this as a reflex result, due partly to the severe irritation of the vagus, partly to a direct affection of the heart-plexus and pneumogastric centre in the brain. He cites, in proof, the experiment of cutting the vagus in animals under the influence of alcohol, when the blood-pressure and heart's action again increase. The circulatory system is the last to succumb to the toxic effects of alcohol, for when all volition has ceased, and the voluntary muscles are paralyzed, the weakened heart continues beating, until, if the intoxication be severe, death results from paralysis of respiration. The long-continued use of alcoholic drinks, particularly in the more concentrated forms, induces a fatty infiltration of the heart-muscle and an atheromatous condition of the arterial walls.

Brain and Nervous System.—The primary effect of alcohol (in small quantities) on the nervous system is a stimulation of the functional activity of the brain. This is a result chiefly of the direct stimulation of alcohol upon the nervous tissue, though the increased force of the heart-beat, its increased frequency, and the greater activity of the entire bodily functions undoubtedly assist its local action. A sense of well-being pervades the body, a greater activity of intellection, increased volubility, and a general exhilaration result, which, enduring for a time, are followed by no depression. Such quantities have little effect on the spinal cord. If the quantity be increased, we have an exaggeration of the foregoing conditions. Mental activity is at its highest, ideas flow rapidly, and thought finds ready expression. Later, the cerebellum and cord begin to show interference with their function, by the muscular incoördination, beginning usually in the tongue and lower lip. If in this condition the quantity of alcohol be again increased, a general incoördination ensues. The tongue refuses to give correct expression, ideas are confused, mental hallucinations, and even a temporary insanity may result. This state is followed by depression, sleep, coma, and even death. The investigations of Schulinus reveal the fact that alcohol induces a distinct change in the contents of the nerve-cells, discoverable by the microscope, the exact nature of which, whether it be a change in the lecithin, fats, or albuminoids, is not positively known. Such a change probably occurs in the last-named stage. Long-continued use of alcoholic drinks to intoxication causes an increase in the connective tissue, the neuroglia, and an atrophy of the nerve-cells. Pure alcoholic drinks, *i.e.*, those which have been carefully freed from the higher alcohols, or aldehydes, produce far less textural, as well as psychical, disturbances, than those containing such impurities. The peculiar condition known as *delirium tremens* most frequently occurs in

those addicted to liquors rich in fusel oil (amylic alcohol). An interesting fact in this connection, to which attention was first called by Richardson, is this, that the administration of fusel oil induces a condition almost identical with that of delirium tremens. The temperament of the subject under such conditions will modify the psychical manifestations; those of a genial temper become merry, noisy, and hilarious, while those of an opposite disposition become morose, taciturn, or quarrelsome. The action, upon the peripheral nervous system, of alcohol is slight, except in toxic doses, when the nerves of sensation are benumbed. (See Alcoholism, under the head of Insanity.)

The sympathetic system—through the increased blood-pressure, in the first stage; the capillary dilatation, and the marked fall of pressure, in the later stages of alcoholic intoxication—shows its susceptibility to this agent. Its action upon the sympathetic in healthy and in inflammatory areas appears to differ, for Binz has shown that there is a contraction in the latter condition of the arterioles and a lessening of the migration of leucocytes.

Temperature.—Small doses of alcohol frequently repeated will cause a slight primary rise in temperature. It is now generally admitted that alcohol in liberal quantities lowers the bodily temperature. All carefully conducted experiments prove this. That large quantities will do so is a matter of almost daily clinical demonstration, either in the healthy or in the feverish organism, but practical use of this agent as an antipyretic has been limited, owing to the comparatively large amounts and the long-continued administration which are necessary. In toxic quantities it is not infrequent for the temperature to drop below the normal from two to four degrees Fahrenheit. On what this fall depends there is much dispute. The causes are multiple rather than single.

1. Since alcohol causes a superficial capillary dilatation, the volume of blood in the integument is increased, and since we have a radiation of heat from the body surface there will be a greater loss of heat than is normal.

2. The functional activity of the sweat-glands is thus increased; hence freer perspiration, increased evaporation on the surface, and cooling.

3. The value of alcohol in the economy is as a heat-producer; but arguments based upon the theory that if it be burned up in the system, the body temperature should rise accordingly, are no more logical than to use the same reasoning for any of the other carbohydrates. Their combustion goes to the maintenance of the normal body temperature as the heat is lost by radiation. This is equally true with alcohol. But by the combustion of alcohol the fats—in part at least—escape oxidation, and are stored up in the tissues. The oxygen which, in the absence of alcohol, would have combined with them, combines readily with the more easily oxidizable alcohol, producing heat.

$$\underset{\text{Carbonic oxide}}{CO_2} + \underset{\text{Water.}}{H_2O}.$$

Now, Frankland has shown that a given weight of alcohol, in burning, produces but seven-ninths as much heat as the same weight of oil (cod-liver). A logical conclusion then is that the temperature of the body, when supported chiefly by alcoholic combustion, will fall.

4. Alcohol in appreciable quantity diminishes cell activity. Since the body-heat depends in part on their activity, anything diminishing the latter will lower the body temperature. According to a well-known law of physics, the separation of complex chemical bodies into ones of simpler composition results in the production of heat. Such changes, in all probability, take place within the cell. If alcohol, therefore, will diminish cell activity, it will lower the body temperature. The fact that a diminished quantity of CO_2 is excreted does not militate against the idea that the alcohol has been burned up, because there is far less C in alcohol, in proportion to the other constituents, than in the fats. Moreover, experimenters have found an increase of the fats and sugar in the blood after imbibition of alcohol, which fact would strengthen the theory that the alcohol is burned.

Rude experience, as well as actual experiment, conclusively teaches us that alcohol diminishes the power of resisting exposure to cold; the explanation being plain enough when the action of this substance on the body-temperature is understood.

On the secretions alcohol has considerable effect. To its action on the salivary and gastric secretions we have already referred. The liver being the first to receive the blood freshly charged with alcohol, in a more concentrated condition than after dilution by the general circulation, is the first to feel its stimulating effect, and the first to undergo pathological changes. The liver-cells are stimulated, and as a result we have an increased flow of bile. The cells enlarge and become infiltrated with fat-globules. The stronger drinks, particularly if taken undiluted and if the practice be persisted in for any considerable period, cause an irritation of the connective-tissue cells in the liver surrounding the portal radicles. A proliferation of the same occurs, and, as a final effect, contraction of this newly formed tissue—as is the case with all newly formed connective tissues—ensues, producing the so-called cirrhotic or hob-nailed liver. With the primary new formation there is naturally an increase in the size of the organ, while the secondary contraction causes an atrophy of the liver-cells, (α) by direct pressure, and (β) by diminishing their normal blood-supply. In those countries where the more dilute alcoholic drinks (wines and beers) are the national beverage, the cases of cirrhosis are unusual; while, on the other hand, the contrary is true where the more concentrated drinks (brandy, whiskey, gin, or rum) are largely consumed. Finally, the portal radicles become so narrowed by the contraction of the connective tissue in which they lie, that the portal circulation is interfered with, thus producing a mechanical congestion of the intestinal, peritoneal, and gastric capillaries, with ascites and watery stools.

The remarkable investigations of Dujardin-Beaumetz upon the action of the various alcohols on the lower animals, have developed, among other things, this very interesting fact, that after the continued use for thirty months of all varieties of pure and crude alcohols, neither interstitial hepatitis, thickening of stomach-wall, nor ascites was induced. The animals chosen for experimentation were pigs, because of the similarity between their digestive apparatus and food and those of man. Congestion of the liver and of the mucous membrane of the stomach and duodenum was induced to a slight degree when ethylic alcohol was used, but it was intense when the higher alcohols were used. When the dose of pure diluted ethyl-alcohol did not exceed one gramme (grs. 15) per kilo. (2 lbs.) of body-weight, no pathological changes whatever were induced!

Kidneys.—The alcohol being in a much less concentrated condition on reaching the kidneys than is the case with the liver, the effects, both physiological and pathological, are less marked. The watery portion of the urine is increased; the solid, at least so far as urea is concerned, is diminished. The increased amount of water excreted is a natural result of the increased blood-pressure; the diminution of urea is due to the lessening of oxidation of the nitrogenous tissues. In these organs, also, the irritating results manifest themselves more slowly than in the liver, but in an exactly similar manner. Eventually the cirrhotic kidney is produced.

Excretion.—Experimenters all agree in this, that not more than sixteen per cent. of the alcohol taken can be found in the excreta. The greater portion disappears in the system. As to its mode of destruction nothing is positively known. None of the intermediate products of its oxidation—aldehyde and acetic acid—have been found either in the blood or in the excreta. If it is destroyed by oxidation, as we have reason to believe, CO_2 and H_2O—both normal constituents of the blood—would be the final products, and could not be identified as derived from alcohol. Through the lungs a small percentage escapes. The heavy odor of the breath after drinking is chiefly due, however, to ethers and higher alcohols which exist naturally in the fermented, and are always added to the artificial liquors. Pure dilute alcohol does

not taint the breath. As to excretion through the kidneys, Binz has shown that under the most favorable conditions not more than three per cent. of the alcohol ingested is excreted by them, thus exploding the theory once entertained that alcohol was entirely excreted unchanged in the urine. A small amount of alcohol is excreted through the skin.

Administration.—The physiological action of all pure liquors does not differ materially from that of alcohol of a similar concentration. Slight differences due to composition will be spoken of in connection with the several liquors.

The physical constitution of the patient, together with the state of health and the result to be acquired, must form the guide to the proper selection and dose. The carefully conducted experiments of Dujardin-Beaumetz, Richardson, and others, agree that one gramme (15 grs.) of absolute alcohol to every kilo (2 lbs.) of body-weight is about the daily limit that can be assimilated by the healthy adult without disturbance of digestion or other injurious consequences. It is true, however, that patients exhausted by the continued fevers can absorb amounts far exceeding the normal limits without injury, in fact, with benefit.

A daily indulgence of two grammes per kilo induces intoxication, and if continued for a few days, will cause loss of appetite, diarrhœa, vomiting of glairy mucus, etc. Finally, a dose of eight grammes per kilo will cause death within from twenty-four to thirty-six hours. In this connection it will be instructive to present the results obtained by Dujardin-Beaumetz as to the average poisonous dose of the various alcohols per kilo of body-weight, sufficient to cause death in from twenty-four to thirty-six hours: Ethyl alcohol, 89 grm. concentrated; propylic alcohol, 2.90 grm. concentrated, 3.75 grm. dilute; butylic alcohol, 2.00 grm. concentrated, 1.85 grm. dilute; amylic alcohol, 1.70 grm. concentrated, 1.50 grm. dilute.

From this it may be concluded that the higher, the degree of concentration of the alcohol the more poisonous will it be. The two last are more poisonous when dilute, because more soluble and better adapted for assimilation. Hence, the importance of administering only pure unsophisticated liquors should be particularly borne in mind.

It may be generally stated that the stronger wines are indicated in the weakened conditions occasioned by long-continued fevers, chronic suppurative processes, and anæmia from frequent hæmorrhages, and for convalescents generally. The red wines, by reason of the tannic acid which they contain, are serviceable where we desire also an astringent effect; hence their use in diarrhœas, locally to ulcers, as gargles, or not infrequently as an injection in gonorrhœa. The sparkling wines, from the CO_2 which they hold in solution, often are efficient in relieving such irritable conditions of the stomach as occur in seasickness, vomiting of pregnancy, or in true cholera. Brandies, whiskeys, etc. (of good quality), are indicated, undiluted, in cases of sudden weakening of the heart's action. Given after a full meal they certainly aid its digestion. This group of alcoholic drinks, when not abused, take the place, with the poor, of the costly condiments of the rich, improving the appetite and aiding digestion. Diluted they can be used where wines are indicated, but not as efficiently. Externally they are frequently employed as alcohol is, to check sweating, as a counter-irritant for bruises, etc.

The beers, ales, and porters are valuable because of the nutritive material which they contain. They are readily assimilated, and are pleasant to the taste, and the bitter principles contained in them, together with the alcohol, cause an increased flow of gastric juice. They are, therefore, prescribed, together with food, as a dietary measure. The diastase which exists in the beer is present in sufficient quantity to aid in the conversion of the starchy foods. Their effect upon the brain is not so pleasant as that of wine, due (according to Rossbach) to the oil of hops, which resembles, in physiological action, oil of turpentine. They are desirable for those who cannot stand the cerebral effects of wines.

Since one gramme of absolute alcohol per kilo (2 lbs.) of body-weight is the average limit per diem that cannot safely be exceeded, a list of the strengths of the more common alcoholic drinks seems here appropriate. From it may be calculated the maximal dose, which it is not desirable to exceed. The following table shows the average strengths of the ordinary liquors, as given by several authorities, with the extremes of variation:

	Per cent.
Brandies, gin, and whiskeys	48 to 56
Sherries and port	20 to 33
Clarets and hock	8 to 11
Sweet Spanish and Italian	13 to 17
Ales and porter	6 to 10
Beers	4 to 6
Stout	4
Kumyss	1 to 2½

The pure natural wines, of course, vary in strength, from year to year, according as the season has produced a very sweet or a sour grape. Sherries and port are frequently fortified by the addition of brandy, which explains their being stronger than the usual eighteen or twenty per cent. strength. *Lewis L. McArthur.*

ALDEHYDE. The aldehydes form a genus of chemical compounds; but *acetic* aldehyde being the commonest member thereof, the word aldehyde, when used singly, is always understood to mean that substance. Acetic aldehyde, C_2H_4O, is, from the point of view of chemical composition, the first outcome of the oxidation of common —ethylic—alcohol. It very closely resembles alcohol in physical and physiological properties, being a thin, colorless fluid of pungent smell and taste; inflammable, miscible in all proportions with water, alcohol, and ether; antiseptic, irritant, and narcotic. It is not used in medicine.

Edward Curtis.

ALDER, BLACK (*Prinos*, U. S.; *Ilex verticillata* Gray; *Prinos verticillatus* Linn.; order, *Aquifoliaciæ*), a medium-sized shrub, with grayish bark, alternate, short, petioled, pointed, and serrated leaves, and small clusters of axillary, minute, whitish flowers; fruit a glossy scarlet, six-celled, six-seeded, persistent berry, in small close clusters along the branches. This plant is common in most parts of the United States, growing along roadsides and moist by-ways and in swamps, and forms, in the autumn, a striking and characteristic portion of our country landscape.

The bark is smooth, grayish or whitish ash-colored, and when dried for medicinal use is in "thin, slender fragments, about one millimetre thick ($\frac{1}{25}$ inch), fragile, the outer surface brownish ash-colored, with whitish patches, and blackish dots and lines, the corky layer easily separating from the green tissue; inner surface pale-greenish or yellowish; fracture short, tangentially striate; nearly inodorous, bitter, slightly astringent" (U. S. Ph.).

No important or definite proximate principles have been found in this drug, which resembles the other hollies in its general properties. Like most bitter barks and woods, black alder has been considered to be tonic and antiperiodic, also, perhaps, slightly astringent; this latter quality has recommended it as a local application to indolent and foul ulcers, and, like most other medicines without definite active properties, it has been used as an alterative in the treatment of various chronic skin and other diseases. The utility of black alder for any purpose excepting a mild astringent tonic is very doubtful, and where it may be serviceable there are better drugs to select from. It is at present, in regular practice, almost obsolete, but in some demand for domestic use.

Dose, internally, from 2 to 4 grm. (ʒ ss. ad ʒ j.). There is no officinal preparation, but it may be given in the regular ten per cent. decoction; dose, 25 to 50 c.c. (f ʒ vj. ad f ʒ xij.), two or three times a day.

Botanical Relations.—*Prinos* is, by Bentham and Hooker and Gray, included in the extended genus *Ilex*, which comprises about one hundred and forty-five species, mostly of tropical America, a few in Europe and Asia, and is the principal genus of the order.

Ilex aquifolium Linn., the common holly of Europe, grows there both wild and cultivated, and is occasionally

cultivated in the United States as an ornamental or hedge-plant. It has similar tonic properties to those of black haw; is also diaphoretic, and has been occasionally used as a popular remedy in digestive derangements, diarrhœa, etc. The berries are emetic and cathartic. A bird-lime was formerly prepared from the bark. The leaves, which are bitter, contain ilicic acid, ilexanthin (a yellow coloring matter), and the bitter principle ilicin, none of which are obtained in complete purity. The latter has been used as an antiperiodic, in doses similar to those of quinine, but has fallen into disrepute.

Ilex opaca, American holly, a good-sized tree, has qualities similar to the above.

Ilex vomitaria Linn., and other species act as bitter cathartics or emetics.

Ilex paraguaiensis Lambert, contains caffeine (see Maté).

Allied Drugs.—The number of bitter drugs which in moderate doses may act as mild tonics, and in large ones certainly derange the digestion, is very large; of these, too, a considerable proportion have been proposed as substitutes for quinine; none of them have held their place as antiperiodics; most of them, it must be confessed, have a little value as tonics; but while there is an abundance of typical bitters, like the gentians and quassias, it is hardly worth while to use them. If a laxative astringent or stimulant is needed in addition to the bitter, it can easily be added to the pure bitters. For list of bitter tonics see Gentian. *W. P. Bolles.*

ALEPPO EVIL. (Synonyms: Delhi boil, oriental sore, impetigo annua, mycosis cutis chronica, lupus endemicus; Fr., *Bouton d'Alep, bouton du Nil, bouton du Caire, bouton de Biskra, bouton de Bagdad, bouton du Scinde, bouton de Bombay;* Ger., *Beule von Alep, Delhi-Beule, Jemen-Beule, Biskara-Beule;* It., *gavocciolo d'Aleppo;* Arabic, *habab el seneh*, one-year ulcer; Turkish, *dous el kourmati*, date disease; Persian, *salek.*) Definition: A non-contagious, indolent, and very intractable sore, commencing as a papule, terminating as an encrusted ulcer, and producing a permanent cicatrix like that of a burn; found chiefly on the skin of the face, neck, and dorsal aspect of the forearm, hand, and foot, and affecting both natives and foreign residents in many parts of Asia and Africa. The lesion is either single or multiple, usually multiple. Among the natives of places where it is endemic, it generally occurs during childhood, and it has even been seen in children at the breast; it may occur in persons of any age. In Aleppo, where the disease was first observed (by Richard Pococke, in 1745), it is said that not one of the native inhabitants escapes. It may be reproduced by inoculation; it attacks dogs, and perhaps horses, as well as men.

Etiology.—Nothing at all definite is known as to the cause or causes of this, as yet, imperfectly understood disease. Drinking-water (as in the case of the water of the Koweik River at Aleppo), parasites, bites or stings of insects, the influence of climate and of particular seasons, general insanitary conditions, lupus, and syphilis, have all in turn been held to blame for its causation.

Geographical Distribution.—An exanthematous affection, more or less like the original Aleppo evil, observed and described by Pococke and the brothers Russel, in the middle of the eighteenth century, has since that time been noted by various authors as prevailing endemically in Egypt, in the Arabian Peninsula, in the Valley of the Euphrates, at Bagdad and Mosoul in the Valley of the Tigris; at Basra, near the Persian Gulf; at Ispahan, in Persia; in India, especially its northwestern portion; in Algeria, Morocco, the Sahara, and the Island of Cyprus; perhaps in China, and, according to Rigler, even in Hungary, Siberia, the Polynesian Archipelago, and New Zealand. Whether it be one and the same disease which prevails in all these localities, many of them so widely separated the one from the other, seems reasonably open to doubt, especially in view of the conflicting statements of authors; and it is equally evident that, until Aleppo evil, or oriental sore, has been more accurately observed and more carefully differentiated as a special form of disease, no adequate or satisfactory account can be given, either of its nature, etiology, or appropriate treatment.

Symptoms.—Leaving out of discussion, so far as possible, the points of dispute in the descriptions of this malady, it would appear that its chief characteristics are as follows: There are no prodromal symptoms. The initial lesion characteristic of the first stage of the disease is a small, reddish papule appearing on the skin of the face, neck, or extremities, and increasing slowly in size for several months, desquamation of the cuticle over the papule occurring after a time. During the second stage, or period of softening, a vesicle (or vesicles) appears on the surface of this now enlarged papule; the vesicle bursts and discharging its contents, of a sero-purulent nature, a scab or crust is produced. This scab is of varying thickness and color, sometimes adherent, sometimes non-adherent. Under it is an ulcer, having a diameter from several millimetres up to eight centimetres in length; the ulcerated surface may be excavated or not excavated, it may be smooth or be covered with prominent granulations. One writer (A. Barralier, in "Nouveau Dictionnaire de Médecine et de Chirurgie") describes the *bouton d'Alep* as surrounded, during this stage, by a narrow areola, dotted over with little tubercular prominences, and he quotes Dr. Suquet, of Beyrout, as testifying to the existence of anæsthesia in this areola; he also states that at times the ulcer reposes on an indurated base, having an extent greater than that of the ulcer itself. Sir Joseph Fayrer (in Quain's "Dictionary of Medicine") speaks also of induration in his account of Delhi boil. In this connection it may be of interest to state that Virchow regards the various forms of oriental sore as belonging to the syphilides, while Hirsch considers them as a variety of lupus. The duration of the stage of softening or disintegration is usually about five or six months.

The third and final stage is that of cicatrization. The cicatrix varies, of course, according to the severity of the preceding ulcerative stage; it is not generally depressed: the process of cicatrization occupies usually about two months. As a rule the whole duration of the disease is about one year; it may not be so long, it may be much longer. The natives in Arabia and Syria call the disease "one-year ulcer." There is a general tradition that it can occur but once in a lifetime. When the lesion is single, the name *male* has been applied to the button or papule; where several large papules have appeared, each surrounded by a number of smaller ones, the name *female button* has been used to designate the variety. (In one case, of unusual severity, reported by Guilhou, seventy-seven of these *female buttons* existed.) Aleppo evil is, for the most part, a painless affection, and is not necessarily accompanied by any febrile movement, or other evidences of general constitutional disturbance.

The *prognosis* is good; the cicatrices are, however, sometimes very disfiguring.

Treatment.—There is, of course, no specific treatment for a disease so ill-defined as is the oriental sore. Tonics, change of climate, the use of caustics, and of the actual cautery and the knife, and many ointments and lotions, etc., have all been used with varying success.

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Huntington Richards.

ALEXISBAD is situated in a deep valley on the southeastern slope of the Hartz Mountains; altitude 408 metres

(1,338 feet). It can be reached in two hours' time from either Quedlinburg or Ballenstedt, stations on the line of the railroad. It possesses two chalybeate springs, the "Alexisbrunnen" and the "Selkebrunnen." A chemical analysis shows that in 1,000 parts of the water of the Alexis spring there are 0.5118 of solid constituents, of which carbonate of iron represents 0.044, and carbonate of manganese 0.025 parts. This water, which possesses no very great therapeutic properties, is used only as a drinking-water. The water from the "Selkebrunnen" contains sulphate of iron (0.056 in 1,000 parts), chloride of iron (0.104), and sulphate of manganese (0.025), and is used for bathing purposes (temperature 11.8° C.—53° F.). The climate may be described as a mild mountain climate, with protection against the raw easterly and northeasterly winds. (Eulenburg.) *H. F.*

ALGIERS. Algiers, the largest town and capital city of the French colony of Algeria, lies almost due south of Marseilles, upon the Mediterranean coast of Africa (Lat. 36° 47′ 20″ N., Long. 3° 4′ 32″ E.). The population in 1866 was 52,614. As seen from the deck of an approaching steamer, the appearance of the city is exceedingly picturesque and striking, its compact mass of dazzlingly white houses, having the form of a triangle, whose base rests upon the western shore of the bay, while its apex climbs almost to the summit of the range of hills shutting in the bay on that side, and culminates at the Kasbah, or former palace of the deys, some five hundred feet above the level of the sea.

Running along the water-line of the city is a well-built quay, backed by a series of stone arches which support a wide and handsome promenade terrace, or boulevard. The Place du Gouvernement and the neighboring streets constitute, together with this quay and esplanade, the newer part of the town built by the French, and occupied by public buildings, warehouses, and the residences of some of the foreign inhabitants. Mustapha Superior, a very pretty suburb lying on the hillside east of the city, contains many villas, and is probably the most desirable place of residence for invalids intending to pass a winter at Algiers. Another suburb, lying also to the east of the town, is known as Mustapha Inferior, just beyond which, at a distance of two miles from Algiers, is situated the great Jardin d'Essai, an experimental garden under the management of the French government, wherein many varieties of palms and other tropical plants are to be seen growing in the open air. Ste. Eugenie, another suburb of Algiers, also contains villas, but of a residence in these Dr. Bennet ("Winter and Spring on the Shores of the Mediterranean") speaks unfavorably, stating that "they are decidedly objectionable, being at the extremity of the western promontory that contributes to form the bay of Algiers, and exposed, consequently, both to the northwest and northeast winds." As to that portion of the city proper, the old quarter, which climbs the hill back of the French quarter previously described, it is not for a moment to be thought of as a residence for invalids, consisting, as it does, of a compact mass of low, flat-roofed whitewashed houses, intersected by the narrow, crooked, dark, and dirty streets characteristic of an oriental town. Picturesque, indeed, this portion of the city may justly be considered, and a ramble through its dingy streets will well repay the traveller for whom the typical scenes of eastern life possess a fascination, but with its picturesqueness its attraction for the visitor certainly ends.

From its low latitude and its situation within the great Mediterranean basin, as well as from its proximity to the desert of Sahara, the climate of Algiers is necessarily a mild one in winter and a hot and very dry one in summer, having its rainful confined almost exclusively to the colder months of the year, as is the case with all places lying in the sub-tropical region of the Old World. The greater mildness of its winter climate, as compared with that of the Genoese Riviera, is ascribed by Dr. Bennet in large measure to the higher temperature of the hours between sunset and sunrise, the temperature along the Riviera being lowered at night "by down-draughts from the mountains that protect it from the north, the Maritime Alps." Another element in producing this more equable temperature at Algiers is probably the fact that winds blowing from the north must pass over the warm waters of the Mediterranean before they can reach the African coast, whereas on the northern shores of this sea all such winds partake of the character of continental winds, and, notably in the case of the much-dreaded *mistral* of the Rhone Valley and of the *bora* of the upper Adriatic, they are accompanied by sudden and most uncomfortable depression of the atmospheric temperature.

The following data, representing the climatic features of Algiers, have been collected from various sources: The mean annual temperature is 66.5° F., according to the writer in the "Encyclopædia Britannica;" 67.89° F., according to Martin and Folley, quoted by Dr. H. C. Lombard, in his "Traité de Climatologie Médicale;" 64.58° F., according to Angot, quoted by Dr. Julius Hann, in his "Handbuch der Klimatologie;" 69.13° F., according to the author of the article on "Climate," in the "Nouveau Dictionnaire de Médecine et de Chirurgie" (Jules Rochard); and, finally, about 68° F., according to Dr. Hermann Weber. The mean of all these figures would give us 67.22° F. as the mean annual temperature of Algiers. On page 448 of his work above cited, Dr. Hann states as follows: "Entirely erroneous mean temperatures have hitherto (1883) been given for Algiers, which showed especially a winter temperature by far too high. The figures of our table are quoted from a recently published work by Angot, and relate to the period between 1860 and 1879." For the eight months of August, October, November, December, January, February, March, and April the figures of Dr. Hann are as follows:

Aug.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.
77°	67.46°	60.44°	54.68°	53.78°	54.68°	57.02°	61.34°

The mean absolute minimum temperature, he states (on the authority of Angot) to be 38.48° F. Deducing from the above given figures the mean temperature of the three winter months, we find it to be 54.38° F., while that of the seven colder months of the year (October to April) is 58.48° F. The duration of the season for invalids ("Kurzeit"), according to Weber, is from November until the end of April; for this period of six months the average temperature of Algiers, calculated from these same figures, is 56.99° F. There appears to be much difference of opinion respecting the degree of variability of temperature exhibited from day to day. Thus, the writer in Eulenburg's "Encyclopädie" remarks that the changes in temperature during the course of a single day, from one day to another, and from one month to another, are considerable in their amount, and frequently sudden in their manner of occurrence (sind sehr bedeutend und fallen oft sehr plötzlich ein). Weber (loc. cit.) says the daily variations are from 10.8° to 14.4° F. (6° to 8° C.). Rochard (loc. cit.) states that the annual mean of the variation from day to day does not exceed 11.34° F. (6.3° C.), while the difference between the day and night temperatures (variations nycthémérales) is given by him at from 5.4° to 9° (3° to 5° C.). Lombard remarks that the former (variations diurnes) are not extreme, not exceeding 1.45° F. in winter, 2.03° F. in spring, 2.66° F. in summer, and 1.6° F. in autumn. The absolute minimum temperature observed at Algiers during a period of twenty years was 35.6° F., according to the author last quoted.

The following figures for the relative humidity are given by Dr. Hann:

Nov.	Dec.	Jan.	Feb.	Mar.	Winter Mean. Dec.—Feb.
68	73	73	72	69	73

The extreme figures representing this factor of climate during the whole year are given as 16 per cent. and 80 per cent. (Mitchell, quoted by Rochard).

The annual rainfall at Algiers is about 36 inches; Lom-

bard puts it at from 31.49 to 33.7 inches, and gives the following extreme quantities, 21.9 and 42.3 inches. As illustrating the seasonal distribution of the rainfall, the following tables, quoted by Dr. Bennet, will be of interest to the reader:

A.—MEAN RAINFALL AT ALGIERS, 1839–1845.

November	5 inches.	May	1¼ inch.
December	8 "	June	0¼ "
January	6 "	July	0 "
February	5 "	August	0¼ "
March	3 "	September	1 "
April	4 "	October	2¼ inches.
Total	31 inches.	Total	5 inches.

B.—NUMBER OF DAYS AND NIGHTS IN 1843 ON WHICH RAIN FELL.

	Days.	Nights.		Days.	Nights.
November	10	10	May	3	1
December	5	2	June	2	0
January	10	7	July	0	0
February	9	7	August	0	0
March	9	6	September	2	0
April	1	2	October	3	1
Total	44	34	Total	10	2

It will be observed that the mean rainfall for October given in Table A is but little less than that for March, thus bearing out the statement made by Dr. Hann that the duration of the dry season for places lying on the Algerine coast is but five months. The average number of fair days in the course of a year at Algiers is 233. The prevailing wind for the year is the northwest, which frequently blows with great violence. The west is the rain-bearing wind, and is the one which is of commonest occurrence in the winter season. North and northeast winds are those which blow most frequently during the spring and summer months. The sirocco, taking its origin over the heated sands of the great Sahara desert, is most commonly felt at Algiers during the hot season, at which time it is greatly dreaded. This wind, blowing from the southeast, occurs somewhat less frequently during the colder months, at which season it is far less oppressive, and is more easily borne. The sirocco at Algiers is always a dry wind; it is accompanied by clouds of dust, a portion of which, consisting of extremely fine particles of sand, it brings with it from the great desert. Dust, it may be remembered, is one of the pests of the Algerine climate; in great part it is of purely local origin, the character of the soil and the heat of the sun, together with the almost constant prevalence of wind, favoring rapid evaporation of the rainfall, and the rainfall itself occurring chiefly in the form of heavy and not very protracted showers. A fall of snow at the city of Algiers itself is an extremely rare phenomenon; in the elevated country back from the coast, known as the Hauts Plateaux, snow falls quite frequently, and at times to a considerable depth. The water-supply of the city of Algiers is abundant. Concerning the character of the water, the writer has no exact information; but from the absence of adverse comments in the works of the various authors consulted, he deems it probable that it possesses no deleterious qualities.

The mildness of its winter climate, together with the moderate percentage of relative humidity in the atmosphere and the great preponderance of clear skies and of bright, sunny weather, which it enjoys at all seasons, combine to render Algiers a desirable, pleasant, and beneficial place of residence during the winter and early spring months, for invalids suffering from pulmonary phthisis and from certain other affections of the respiratory system. For such cases its climate is recommended by Lombard, Rochard, and Weber. The last-mentioned writer speaks of the climate as exercising also a beneficial influence upon chronic diarrhœas and upon the sequelæ of dysentery.[1] Lombard specifies chronic bronchitis, asthma, and phthisis as diseases likely to be benefited by a sojourn at Algiers, and he calls attention to the remarkable immunity from pulmonary phthisis enjoyed by the native population as well as by the soldiers of the French army stationed in Algeria. This immunity is greater upon the sea-coast than it is on the higher ground lying further inland. The writer on Algiers in "Eulenburg's Encyclopædia" speaks, on the contrary, in very unflattering terms both of the climate of the city and of its desirability as a winter residence for invalids. He lays great stress upon the variability of the climate and its liability to sudden changes of weather, and warns all invalids who are unpleasantly affected by such changes, all asthmatics and persons subject to attacks of diarrhœa, rheumatism, and intermittent fever, that they would do well to avoid the place. How far the unfavorable comments of this writer may be justified, the writer is not in a position to know from personal experience; but, judging from the meteorological data quoted from reliable sources in the present article and from the favorable comments made by Lombard and other writers of repute, he deems it not improbable that the contributor of the article in Eulenburg has overestimated the unpleasant features of the Algerine climate.

Huntington Richards.

[1] Chronische Bronchitis, besonders mit Reizhusten, Emphysem, Ueberreste von Pneumonie und Pleuritis und Phthisis im ersten Anfang bilden das geeignete Material; auch Chronische Diarrhöen und Folgezustände von Dysenterien sind geeignet (Ziemssen's Handbuch der allgemeinen Therapie, Band ii., S. 80).

ALHAMA D'ARAGON (Lat. 41° 15′ N.; elevation above the sea, 1,880 feet), a Spanish village on the Saragossa & Madrid Railway; a spring of moderately high temperature (93.2° F.), and of slightly mineralized, almost tasteless water. Total solids 6.1 per 1,000. The place is frequented chiefly by rheumatic patients. The bathing establishments are on a grand scale. (Eulenburg.)

H. F.

ALICANTE. The city of Alicante lies upon the shore of the bay bearing the same name, on the eastern or Mediterranean coast of Spain, and about forty miles south of the middle point of that coast (Lat. 38° 20′ N., Long. 0° 30′ W.). The population of the town is 31,500. Extending in the form of a crescent along the northern shore or head of the bay, and nestling at the base of a rocky eminence some 400 feet high, the town is tolerably sheltered from north and northwest winds. The streets near the port are wide and clean. The water supply, according to Dr. J. H. Bennet ("Winter and Spring on the Shores of the Mediterranean," fifth edition, 1875), is derived from one large spring and from rain-water tanks. "Lippincott's Gazetteer" (1864) states that in its character the water is not good, being impregnated with the salts of magnesia, but in the point of abundance it would appear to be sufficient for the needs of the town. Up to the time of Dr. Bennet's visit, in the spring of 1869, no hotel existed at Alicante which came up to the standard of comfort and convenience desirable for invalids in search of a good sanitary resort. Perhaps this defect may have since been remedied. The climate of Alicante is a mild and a very dry one. The annual rainfall is only 16.98 inches; of which (according to Lorenz and Rothe, quoted by Dr. Weber in Ziemssen's "Handbuch der Allg. Therapie") 20.7 per cent., or the extremely small quantity of 3.5 inches, falls during the winter months. From the other percentage figures given by these authorities, the average rainfall during the spring at Alicante would be 5 inches, during the autumn 6.4 inches, and during the hot summer months only 1.9 inch! The percentage of clouds prevailing in the sky of that portion of Spain in which Alicante is situated is much lower than is found in any other part of Europe, Italy and Greece being included. The neighboring province of Murcia bears the name among the Spaniards of "el reino serenissimo," a title justly bestowed upon it for this reason (Hann's "Klimatologie"). Figures for the relative humidity of Alicante itself the writer has not been able to find, but at Valencia, lying some eighty-five miles north of Alicante, the mean relative humidity of the year is 66 per cent., and it varies but little from season to season (Weber, loc. cit.). The mean annual temperature of Alicante is 64.4° F.; the mean temperature of the winter season nearly 53.5° F.; according to the same author, who quotes these figures from Francis. For Murcia, lying about fifty miles southwest of Alicante, the yearly extremes of tempera-

ture are 26.5° F. in winter, and 106.5° F. in summer; the mean temperature of January being 48.7° F., that of April 60.2° F., that of July 79° F., and that of October 64.5° F. These latter figures are quoted from Hann's "Klimatologie." The east wind, or "Solano," is the rain-bearing wind for the eastern coast of Spain. The "Leveche," a very dry, hot wind from the Sahara, reaches the southeast coast between the Cabo de Gata and the Cabo de Nao.

Dr. Weber says (1880) that there is good accommodation to be found at Alicante. He speaks favorably of the effect of the climate upon certain cases of phthisis ("einzelne Fälle von apyretischer, ruhender Phthisis"). "Alicante," says Dr. Bennet, "appears to me decidedly the most favorable health station that I have seen on the southeastern coast of Spain. . . . There is a *Huerta*, or irrigated valley, it is true, connected with Alicante, but it is situated at some distance north of the town, . . . and there are no rice grounds to produce malaria as at Murcia and Valencia." On account of its greater dryness, Dr. Bennet questions whether Alicante would be as beneficial to certain classes of patients as the Riviera of France and Italy.

Huntington Richards.

ALIMENT. Food or aliment is matter which, in conjunction with the air, supplies the elements necessary for the maintenance, growth, and development of the organism, and is thus the source of the power on which the vitality of the organism is dependent. Hence, in the broadest sense, true aliment is a mixture of food-stuffs and drink, together with the air from which comes the oxygen necessary for the oxidation of the former and by which force is produced. Again, physiologically considered, true aliment, especially in the animal kingdom, is to be distinguished from so-called "food" as being only that portion of the food which is either itself directly soluble and diffusible, or convertible by the digestive juices of the body into soluble and diffusible products, and thus capable of being absorbed by the blood.

The aliment of vegetable organisms is quite different from that of animal organisms. Moreover, the nature of the processes involved is likewise quite different.[1] The vegetable organism by a synthetical process—a building up of more complex bodies from simpler ones—derives its nourishment from the inorganic world; its cells appropriate such of the inorganic principles as are needed for its growth and convert them under the influence of the sun's rays into organic compounds which enter into its own structure.

The animal organism, on the other hand, does not possess this power, and thus we look to the creative power of the vegetable kingdom as the source, either directly or indirectly, of the aliment of animals. Moreover, the vegetable matter which thus serves as food, not only furnishes the material necessary for the growth and life of the organism, but it contains in addition, stored up within its molecules, a certain amount of latent force derived from the solar force originally used in its construction.

Animal organisms, by a process of transformation quite the reverse of synthetical, convert the preformed animal or vegetable organic matter into allied or simpler forms which are absorbed into their own tissues. Animal food approximating more closely in composition with the body to be nourished by it, is more easily appropriated, and probably with less expenditure of energy, than vegetable products. Animal food, moreover, possesses stimulating properties, due without doubt to the crystalline nitrogenous bodies contained in muscle-serum. Organic matter once entered as a part of an animal organism and applied to the purposes of life is decomposed or broken apart, and its decomposition products are ultimately reconverted into inorganic principles. There is thus a complemental relationship between vegetable and animal life and the inorganic world. The plant by a selective action appropriates as an element of nutrition certain kinds of mineral matter, together with nitrogen in the form of ammonia and nitrates, from the soil in which it grows, at the same time drawing from the air carbon in the shape of carbonic acid, while hydrogen and oxygen are supplied to an unlimited extent in the form of water. The vegetable products thus formed serve in turn as the food of animals, while the latter at every breath pour forth carbonic acid and water, which ultimately find their way again, more or less modified, into the tissues of plants. These, together with the nitrogenous excreta, products of the metabolism of life, and the post-mortem decompositions which follow, continually serve in their variously modified forms as agents by which the conservation and transference of energy is accomplished.

The alimentary products found in nature can be separated by chemical analysis into several well-defined substances, none of which are usually found free in nature. These chemically distinct substances are termed the alimentary principles. Many of them are found in both animal and vegetable foods, as, for example, certain fats, casein, and some forms of albumin, although in the case of the two latter examples there would appear to be some few minor points of difference both in percentage composition, and in chemical reactions. Others are to be found only in one kingdom, as starch in the vegetable, or collagen, the gelatin-forming substance, in the animal.

Now since food is the source from which the various elements of the body are supplied, it is evident that to fulfil its purposes food must contain all of the elements present in the body. These are of course not free, but in a state of combination, for it is only in the latter case that they are of service as food, and as Pavy remarks, "the combination must have been formed by the agency of a living organism—the combination must, in other words, constitute an organic product." Aside from the elements which appear as inorganic salts, there are in the body at the most but six elements, two of which are present only in small quantity and are apparently much less important. These six elements are carbon, hydrogen, nitrogen, oxygen, sulphur, and phosphorus. Any substance which as food is to satisfy the requirements of life, must contain at least the first four of these six elements, in addition to inorganic salts and water.

Various classifications of food have been from time to time proposed, based mainly either upon physiological or chemical grounds. Popularly, aliment is frequently divided into food and drink, without, however, any suitable reasons, since the mere fact of a food being in solution does not preclude the possibility of the presence of even a large amount of solid matter, as for example in the case of milk, while, on the other hand, butcher's meat contains on an average sixty to seventy-two per cent. of water. Hence, food should be considered as including both liquid and solid matter. The most natural and comprehensive classification of foods is that based primarily on chemical composition and origin, viz., organic and inorganic—that is, chemical combinations of elements producible only through the agency of living cells, and secondly, inorganic compounds absorbed from the mineral kingdom, and thus intimately mixed with the former. The inorganic portion of food consists simply of water and various saline compounds. The organic portion may be advantageously subdivided into two groups, nitrogenous and non-nitrogenous, based simply on the presence or absence of the element nitrogen. The nitrogenous alimentary principles contain carbon, hydrogen, oxygen, and nitrogen combined in varying proportions, and generally also small quantities of sulphur and frequently of phosphorus. The non-nitrogenous principles contain only the three elements carbon, hydrogen, and oxygen. These are in turn further subdivided according to the relative proportion with which the carbon and hydrogen unite with oxygen, viz., into fats and carbohydrates; the former consisting of carbon and hydrogen united to only a small amount of oxygen, as in the case of tripalmitin, $C_{51}H_{98}O_6$, the latter of carbon with the hydrogen and oxygen always in such proportion as to form water, as in the case of cane-sugar or saccharose, $C_{12}H_{22}O_{11}$; hence the name carbohydrates. These two divisions of the non-nitrogenous principles not only differ in percentage composition, but they are likewise widely divergent both in

chemical and physical properties. Following is a partial classification of foods:

- 1. Inorganic.
  - a. water.
  - b. salts.
    - calcium sulphate and phosphate.
    - magnesium sulphate.
    - potassium chloride, phosphate, and carbonate.
    - sodium chloride, phosphate, and carbonate.
    - iron salts.
    - silica, fluorine.
- 2. Organic.
  - a. non-nitrogenous.
    - fats.
      - tristearin. } animal and vegetable.
      - tripalmitin.
      - triolein.
    - carbohydrates.
      - amylaceous.
        - starches.
        - gums.
        - dextrins.
        - cellulose.
      - saccharine.
        - grape-sugar.
        - cane-sugar.
        - milk-sugar.
        - muscle-sugar.
  - b. nitrogenous.
    - gelatinous principles.
      - collagen.
      - chondrigen.
      - gelatin.
    - albuminous principles.
      - albumin. } animal and vegetable.
      - fibrin.
      - casein.
      - syntonin.
      - globulin.
      - vitellin.

Examination of this classification leads us first to notice the importance of water[2] as food. According to Voit,[3] the body of a fully developed man contains 63 per cent. of water, while the body of a growing child contains nearly 66.5 per cent. Any great alteration in the content of water in the animal body is always attended with disastrous results; thus, in diarrhœa, cholera, etc., such large quantities of water are lost as to render the blood quite thick, and even the muscles may lose as much as six per cent. of water. Such loss, if long continued, soon results in loss of vitality and consequent death. It is noticeable, moreover, that a certain proportion of the water contained in the tissues of the body can be removed without difficulty, while a smaller, residual portion, apparently more closely united to the organic matter, can be separated only with great difficulty; this is well illustrated in the simple drying of dead muscle-tissue. Removal of the water from low forms of animal life by drying them at the ordinary temperature, or at a temperature below the coagulating point of their body protoplasm, causes them to lose all appearance of life, but in such condition they will again absorb the water lost, and return to their former appearance and vitality. Increase of water in the organism beyond the normal amount is usually associated with an unhealthy condition of the body. Various investigators have likewise demonstrated that there is a close connection between the percentage of water in the body and the diet, irrespective of the water taken as drink. Thus Voit has shown that a bread diet continued for some time renders the body more watery than normal. In one experiment with a cat the amount of water in the brain and muscles was increased three to four per cent. Increase of fat in the body is usually attended with a diminished percentage of water.[4] A vigorous, well-nourished man possesses organs much poorer in water than a badly-fed person. Forster[5] has figured that under normal conditions a person living on an average diet takes daily 2,215 to 3,538 grammes (about 6.5 pounds avoirdupois) of water. It is easy to see, however, that a great variety of circumstances, of diet, exercise, temperature, etc., may excite a modifying influence on the amount of water taken into the system during the twenty-four hours. The figures just given do not, however, represent all of the water, since a variable amount is formed within the body by oxidation of the hydrogen contained in the organic alimentary principles. Thus, according to Voit, in the case of a hungry man, 32 grammes of hydrogen in the form of organic matter were oxidized to 288 grammes of water during twenty-four hours.

It is thus plainly evident from the foregoing that water is a necessary constituent of the body, and as one of the alimentary principles is a decidedly important one; yet we need to understand its true significance. It does not itself undergo any chemical change, and is thus not concerned in the production of force, though it aids chemical change in supplying, by its presence, a condition absolutely necessary for its occurrence in other bodies.

The inorganic salts, as Pavy remarks, "stand, if not to the full extent, nearly so, in the same position as water, as regards the non-possession in itself of force-producing properties." The mineral matters are more closely concerned in the structure of the organism than in the development of power, and this is true both of the animal and vegetable organisms. They are particularly necessary in the developing animal body, and of all the forms of mineral matter none is so important and so widely distributed as calcium phosphate. This salt is seldom, if ever, absent from any structural element of the body, and its intimate union with many of the nitrogenous principles, particularly the albuminous bodies, is so decided that only with the greatest care can this salt be completely removed without changing the nature of the albuminous body;[6] indeed, in many cases there would appear to be a chemical combination between the proteid body and inorganic salt. Mineral matter is needed, not only for the growth and nutrition of the skeletal portions of the body, but it is also needed in the structure of the softer tissues as well as in the formation of secretions; thus the acid of the gastric juice has its origin in the chlorine of sodium chloride, or common salt, while the alkalinity of the pancreatic secretion, as well as that of some of the other fluids of the body, is due to sodium carbonate. Moreover, the removal of carbonic acid by the lungs, through the agency of the venous blood, could hardly be accomplished were it not for the alkalinity of that fluid. In many juices of the body, inorganic elements are held not only in solution, but quite firmly united with the more characteristic organic matter, as in the sodium salts of the bile acids, and in some instances they can be removed only by decomposition of the compound. The excess of salts taken into the body, by the food or other means, and that which becomes free by decomposition within the body, is easily removed through the urine and fæces.

There is still other evidence that the various inorganic salts of food serve definite purposes in the body. The two alkalies, potash and soda, so widely distributed and so closely allied in their chemical properties, cannot be made to replace each other in the living organism, while the same is likewise true, to a certain extent, of the alkali earths, lime and magnesia. Thus a qualitative, and also a quantitative selection of inorganic matter is noticeable in the body, particularly in the blood, where the corpuscles contain the greater portion of the potash salts and phosphates, while in the serum, soda salts and chlorides are in excess. Again, it is quite noticeable that potash salts predominate in the formed tissues of the body, while soda salts are characteristic of the fluids.

Forster's[7] experiments on pigeons with food poor in salts, and on dogs with powdered meat from which the greater portion of inorganic matter had been removed by extraction with hot water, fat and carbohydrates being afterwards added, showed that these animals could not bear the loss longer than four to five weeks without great suffering, and, finally, death. In fact, it is evident, from physiological experiment, that an organism supplied with all organic food-stuffs and water can live only for a limited time without mineral matter. For a time the body draws upon the inorganic matter stored up in its own tissue;[8] but this failing, and that naturally present in the organic foods being removed, death soon results from lack of inorganic aliment.[9] In the ordinary diet of men and animals, sufficient salts are generally contained in the fat and proteid foods to furnish the required amount of mineral matter. As to the actual quantity of inorganic matter needed to counterbalance that withdrawn from the body in twenty-four hours, we can hardly say. The content of ash contained in the smallest amount of food necessary to keep up the vitality of an organism would give an approximate answer to this question. This Bischoff and Voit attempted to ascertain by experimenting with a dog weighing 31 kilogrammes (68.3 pounds), the daily food in this case containing 6.5 grammes (100.3 grains) of ash. The excretion of ash, however, as Voit has pointed out, is quite different in the hunger condition

from what it is during a plentiful diet; for, in the case of hunger, the inorganic matter of the organs is drawn upon, the salts passing into the excreta, thus keeping the percentage composition of these fluids for a time constant.

The importance of iron, or iron-salts, as aliment, is hardly second, certainly not in the case of the higher animals, to lime salts. The position which it occupies in the hæmoglobin molecule, on which the blood depends for its power of carrying oxygen, would alone indicate this. Boussingault [10] has determined the amount of iron in a sheep of 32 kilogrammes weight to be 3.38 grammes, = 0.151 per cent. [11]

Of the non-nitrogenous foods, the fats or hydrocarbons which, according to Liebig's classification, come under the head of elements of respiration or calorifacient principles, are particularly applied to the production of heat and other forms of force. They also appear to be concerned, to a certain extent, in tissue development. The neutral fats alone are important as foods. The free fatty acids and glycerine are seldom present in sufficient quantity to have any significance. The more important fats are tristearin and tripalmitin among the solid, while among the more easily melting fats triolein alone occurs. These are simply neutral compounds, formed by the union of a triatomic alcohol, glycerine, with three molecules of a monatomic fatty acid. The fluidity of a fat depends on the amount of olein present; thus, beef-fat, which contains more palmitin and stearin, melts at 41° to 50° C., while goose-fat, which contains large quantities of olein, melts at 24° to 26° C. The following table gives some idea of the amount of fat contained in a few common foods:

	Per cent. of fat.
Fat-tissue of swine	92.21
Fat-tissue of beef	88.88
Fat-tissue of mutton	87.88
Butter	85.0 to 90.0
Eggs	12.0
Fat meat	5.0 to 12.0
Milk	3.0 to 4.0
Cheese	8.0 to 30.0
Vegetables	0 to 3.0
Nuts	53.0 to 66.0

All animal fats show a remarkable uniformity in elementary composition, containing on an average 76.5 per cent. C, 11.90 per cent. H, and 11.60 per cent. O. The chemical composition of the fats indicates the importance of these principles as heat-producing agents. In the carbohydrates and other allied principles, the hydrogen and oxygen are present in such proportion as to form water (starch $C_6H_{10}O_5$), while in the fats, as in tripalmitin ($C_{51}H_{98}O_6$), only 12 atoms out of 98 have their combining equivalent of oxygen contained in the compound, and hence the remaining hydrogen atoms, as well as all of the carbon, are free for oxidation. And since the quantity of heat produced is dependent upon the amount of chemical action or oxidation, it follows "that a given quantity of fat will have the power of appropriating about 2.4 times as much oxygen as the same quantity of starch, or, in other words, will develop about 2.4 times as much heat in the process of oxidation, and hence has about 2.4 times as much value as a heat-producing agent" (Pavy). But while the fats are especially important for the production of heat, and for forming the basis of adipose tissue, they are likewise essential for tissue development generally. The great importance of fat in food and of that deposited in the body is to be found in the aid which it furnishes to the hungry organism in developing its wasted tissue. A purely proteid diet to a person poor in fat necessitates a large amount of the former to sustain the weight of the body, indeed more than the intestines are capable of absorbing. But a mixture of fat with the proteid matter diminishes both the amount of circulating albumin in the body and the proteid metabolism. The proteid food is needed to sustain the bodily wants, and at the same time to prevent the loss of fat. Still, it is not possible to convert a poor body into a body rich in fat and proteid material by a simple albuminous diet; fats or carbohydrates are needed, admixture of which diminishes the work of the organism. The energy of the active cells of the body is then only in part used for the decomposition of albumin, the remaining energy being applied to the decomposition of fatty matter. This is well illustrated by the increased metabolism of fatty matter during muscular exertion. In the words of Voit, "muscular work renders the cells capable of decomposing more material, and, after the use of the disposable albumin, the fat is brought into requisition. Thus nothing is of greater influence upon fat metamorphosis than work." (See Nutrition.)

The carbohydrates being especially found in the vegetable kingdom, belong essentially to a vegetable diet. A few, however, occur in animal food, as glycogen and sugar in the liver, lactose in milk and the sugars, as inosite present in small quantities in muscle-tissue. In composition, the carbohydrates are all alike in containing hydrogen and oxygen in such proportion as to form water, but the exact chemical constitution of the bodies is not known. As a class they constitute very easily decomposable material, readily breaking down into carbonic acid and water, and as food-stuffs they are especially prominent in causing an accumulation of glycogen in the liver. They are, moreover, without doubt the source, in part, of the fat in the body. Sugar or starch is always present in fattening foods, and although it is doubtful whether the fat is formed directly from the carbohydrates, still the association of fat and glycogen in the hepatic cells, and the fact that the former is increased by such diets as tend to increase the latter, would in itself tend to indicate a connection between carbohydrates and the production of fat. (For a discussion of this question see Nutrition.) Carbohydrates, like the fats, tend to diminish proteid decomposition, and even more decidedly; and as they are likewise able to prevent the withdrawal of fat from the body (according to Voit 175 parts of carbohydrates accomplish as much as 100 parts of fat) it is evident that they possess the power, in a high degree, of taking the rôle of the fats. Moreover, while the carbohydrates are being oxidized, the fat formed from albumin is spared, and Voit [12] considers that in both carnivorous and herbivorous animals the main action of carbohydrate food (so far as its connection with fat is concerned) is to protect the fat already formed, and that in no case does the fat itself have its origin in the carbohydrates, but in the carbon surplus of proteid food. (See Nutrition.) Carbohydrates differ from fats in that they contain, weight for weight, less potential energy than the latter. They differ likewise in being more easily digestible.

The nitrogenous or albuminous and gelatinous principles, are all very much alike in general composition, showing, however, some decided differences in their content of nitrogen. Most of the nitrogenous principles occur in the solid form, both in the animal and the vegetable kingdom, though a few are to be found dissolved in the fluids of the organism. Voit [13] has estimated from analyses by Bischoff, that in a fully developed human body weighing 68.65 kilos (151.3 pounds) there would be contained when dry (at 100° C.), 22.4 per cent. of albuminous matter, and 14.8 per cent. of collagenous tissue. The excretory products of animal organisms contain such a large percentage of nitrogen, it is evident that the nitrogenous principles must play an important part in supplying the needs of the body. Of these the albuminous principles are the most important, and for man and animals albumin, in its various forms, constitutes a vital food-stuff, without which life cannot be long sustained. As the content of albuminous matter in the body is large, and as all the active cells of the body are protoplasmic, it follows that albumin must be supplied in considerable quantity to take the place of that used up in the ordinary processes of life. It is, however, widely distributed through both the animal and vegetable kingdoms; notably in the casein of milk, egg-albumin, and myosin of muscle in the animal kingdom, and in the coagulable albumin, vegetable casein, legumin, and congluten of the legumins, and gluten of wheat and rice, etc., in the vegetable kingdom. The albuminous principles, moreover, in view of their containing all of the organic elements necessary to life, are capable, when used in conjunction with the inorganic principles, of supplying alone all the needs of the body; still such a diet would not be an economical one for the system, owing to the large amount of proteid matter

which the system would be obliged to work over, together with the subsequent removal of the nitrogen, in order to obtain the requisite amount of carbon. This is easily seen from the composition of pure egg-albumin with its 52 per cent. of carbon, when compared with a fat, as tripalmitin with 76 per cent. of carbon, or with a carbohydrate as saccharose with 42 per cent. of carbon and 51 per cent. of oxygen. It is evident, from these figures, that a judicious mixture of an albuminous food-stuff with a carbohydrate or fatty food-stuff, would give a food containing the required carbon and nitrogen, assimilable with less expense to the body. Liebig's theory, that nitrogenous food is used wholly in building up albuminous tissues, as the muscle, and other forms of protoplasm, and that the nitrogenous excreta are formed wholly from the metabolism of the above tissues, is now known to be incorrect, and that in reality proteid food-stuffs may, in one sense, be respiratory and also give rise to the storing up of fat as well as the production of force. In fact, in the decomposition of proteid matter within the body, into the ultimate product, urea, which is excreted, there results a complementary hydro-carbonaceous residue, apparently applicable to the production of force. At the same time, the chemically distinct oleaginous and saccharine principles which are together especially concerned, either directly or indirectly, in the production of heat, are likewise of use in force-production, and thus any classification of the alimentary principles based on the physiological grounds advanced by Liebig, is wholly untenable. The view now taken regarding the production of force within the body is that the combination of muscles and nerves is to be considered as a form of apparatus especially adapted to transform the force liberated by chemical action into those other forms of force termed muscle and nerve force. This being the case, any easily oxidizable organic matter will answer the purpose. Hence, to a certain extent, the two groups of nitrogenous and non-nitrogenous alimentary principles are qualitatively alike, in that both may be concerned in the production of force, in the development of heat, and the storing up of fat, although the non-nitrogenous are not distinctly provocative of metabolism. The nitrogenous principles are, however, indispensable to the growth of the tissues of the body, and are likewise indispensable in the production of the nitrogenized ferments, on the presence of which the digestive juices of the body depend for their special action.

Collagenous tissue, comprising the gelatinous principles (organic basis of bone, cartilage, tendons, and connective tissue), cannot supply the place of the albuminous principles; still, Voit[14] has found that nitrogenous equilibrium is established at a lower level of proteid food when gelatin is added, and Foster[15] apparently considers that in the metabolism of gelatin it rapidly splits up into a urea and a fat moiety, but is unable to imitate the other function of proteid matter, or to take part in the formation of living protoplasm. (For nitrogenous metabolism see Nutrition.)

There are a number of crystalline nitrogenous substances occurring in both the animal and vegetable kingdoms which are present in greater or less quantity in food, such as creatin and other like proteid decomposition-products, contained, for example, in some quantity, in Liebig's *extractum carnis;* also the vegetable alkaloids. None of these, however, are of any value as food; the majority of them pass quickly out of the body, but little if any altered, although one or two, as asparagin,[16] are said to slightly diminish proteid metabolism. The more highly complex lecithin, present in the yolk of the egg, in the brain, etc., may possibly be placed among the true foods, though no direct experiments have been tried to demonstrate its action. The main action of the alkaloidal substances, as the caffein of coffee, is that of a stimulant, acting especially upon the fatigued nervous system, though many of the common alkaloidal infusions made from roots, leaves, and berries may be somewhat nutritious from the albuminous and fatty matters which they contain, as is the case with cocoa.

The drinks commonly used as food may be divided, aside from water, into the alcoholic, acidulated, saccharine, gaseous, and infusions of various substances, such as tea. The alcoholic drinks contain from about sixty per cent. of alcohol, as in rum, brandy, and whiskey, to from two to ten per cent., as in beer and light wines. Malt liquors contain, perhaps, the largest number of constituents, among others there being sugar, dextrin, gluten, and various substances from the hops. The exact influence of alcohol, or its value as a food, is uncertain. It is, without doubt, decomposed in great part within the body,[17] and split up into simpler substances; but its main action is doubtless that of a local excitant to the mucous membrane of the alimentary canal, possibly thereby stimulating digestion, and as a stimulant upon the central nervous system and upon the circulation.

Food, as eaten by man and animals, is a natural mixture of the various alimentary principles described. Seldom are the isolated principles eaten by themselves, other than in the case of sugar and salt, or pure fat. It is the function of digestion to separate the individual principles from this natural mixture, by which means they are separately absorbed. The behavior of animal and vegetable food is quite different in the alimentary canal, which difference is dependent more upon the quality of dry substance contained in the latter food than upon its quantity. Vegetable food yields a much larger percentage of indigestible residue, and is in itself much less easily digestible, owing to the fact that it is more or less enclosed in the difficultly soluble cellulose, while animal food is free. Moreover, vegetable food, as a rule, is less easily absorbed, and, as it contains a less percentage of nitrogen, a much larger quantity is needed to furnish a certain amount of this element than in the case of animal food. Again, the large quantities of starch contained in a vegetable diet tend to produce an acid fermentation in the small intestines, with formation of butyric acid, together with marsh gas and hydrogen, which causes the frequent intestinal excretions of herbivorous animals.

The following tables give the percentage amounts of the alimentary principles contained in several of the natural animal and vegetable foods. It is to be borne in mind, however, that the nutritive value of a food depends not only upon its composition but also upon its digestibility.

ANIMAL FOODS.

	Lean Beef.[1]	Salmon.[2]	Halibut.[2]	Eggs.[3]	Cows' Milk.[4]	Calves' Liver.[5]	Cream.[6]
Water	75.90	62.93	75.24	73.90	87.41	72.33	66.06
Solids	24.10	37.07	24.75	26.10	12.59	27.67	34.00
Albuminous	18.36	22.93	18.53	14.10	3.41	20.10	2.70
Collagenous	1.64	..	..	..	..	..	..
Fatty	0.90	12.81	5.16	10.90	3.66	5.58	26 70
Carbohydrates	..	.	..	..	4.82	0.45	2.80
Extractives	1.90	..	..	..	..	..	..
Ash	1.30	1.33	1.06	..	0.70	1.54	1.80

VEGETABLE FOODS.

	Potato.[7]	Rice.[8]	Oatmeal.[8]	Indian Corn.[8]	Horse Beans.[9]	Apples.[10]
Water	74.00	13.00	15.00	14.00	12.50	83.58
Solids	26.00	87.00	85.00	86.00	87.50	16.42
Albuminous	2.50	6.30	12.60	11.10	30.80	0.39
Woody fibre (cellulose)	1.04	..	..	..	3.00	1.98
Fatty	0.11	0.70	5.60	8.10	1.90	
Starch	20.00	} 79.5	} 63.80	} 65.10	} 48.30	5.17
Sugars, gums, etc.	1.09					7.73
Ash	..	0.50	3.00	1.70	3.50	0.31

[1] Bischoff and Voit: Gesetze d. Ernährung des Fleischfressers, 1860, p. 304.
[2] W. O. Atwater: Berichte d. deutsch. chem. Gesell., 16 Jahrgang, p. 1844. [3] Voit: Hermann's Handbuch d. Physiologie, 6, 460.
[4] J. König: Hermann's Handbuch d. Physiologie, 6, 453.
[5] According to Payen. [6] Dr. Letheby's Tables.
[7] According to Payen. [8] Letheby's Tables. [9] Payen. [10] Voit.

In studying the composition of animal substances, with a view to determining their food-value, the percentage amount of nitrogen is the most important point to be ascertained, inasmuch as this element is an index of the amount of albuminous matter present. At the same time it is to be remembered that proteid food-stuffs alone do not constitute an economical diet. A rational diet is to be found only in a judicious mixture of proteids, fats, and carbohydrates. Even milk is not a properly constituted food for a working man, for though it contains both fat and carbohydrate it has too large a percentage of nitrogen (albumin and casein) for the carbon.

It has been found by repeated experiment that an average working man, in order to prevent loss of nitrogen and carbon, requires daily about 18.03 grammes of nitrogen (= 118 grammes of dry albumin), and at least 328 grammes of carbon; and as the 118 grammes of albumin contain but 63 grammes of carbon, it is plain that there would be required 265 grammes in the form of fats or carbohydrates.[18] The following table gives the number of grammes of several common foods necessary to furnish the daily requisite of carbon and nitrogen:

For 18.3 grammes Nitrogen.	Gm.	For 328 grammes Carbon.	Gm.
Lean meat	538	Lard	450
Wheat flour	796	Corn	801
Eggs (18)	905	Wheat flour	824
Corn	989	Rice	896
Rice	1,868	Eggs (43)	2,231
Milk	2,905	Lean meat	2,620
Potatoes	4,575	Potatoes	3,124
Lard	4,796	Milk	4,652

It is thus evident that no one of these substances is in itself a proper food. Lean meat, for example, must have added to it fat or carbohydrate, or both; while potatoes, as an example of a carbonaceous food, require an admixture of nitrogenous matter. Hence a judicious mixture of all the alimentary principles from both the animal and vegetable kingdoms constitutes the food best adapted to the wants of mankind. *R. H. Chittenden.*

1 Wurtz: Chimie Biologique, chapters 1–2. 1884.
2 Hoppe-Seyler: Physiologische Chemie, p. 28.
3 Hermann's Handbuch der Physiologie, vi., 347.
4 Philosophical Transactions, 2, 494.
5 Zeitschrift für Biologie, ix., 387.
6 Aronstein: Pflüger's Archiv für Physiologie, viii., p. 75. Alex. Schmidt: Pflüger's Archiv, xi., p. 1.
7 Zeitschrift für Biologie, vol. ix., 1873.
8 Weiske: Zeitschrift für Biologie, vol. vii., pp. 179 and 333.
9 Forster: Zeitschrift für Biologie, vol. xii., p. 464.
10 Comptes Rendus, 1872, 64, p. 1353.
11 Compare Hamburger: Zeitschrift für Physiolog. Chem., vol. ii, 191.
12 Hermann's Handbuch der Physiologie, vi., 260.
13 Ibid., vi., 388.
14 Zeitschrift für Biologie, viii., 297.
15 Text-Book of Physiology, p. 467.
16 Zeitschrift für Biologie, xv., 261.
17 Pflüger's Archiv für Physiologie, vol. xxxii., 398.
18 Voit: Hermann's Handbuch der Physiologie, vi., 497.

ALIMENTATION, RECTAL. The literature of this subject does not date back very many years. Dr. Austin Flint says that Samuel Hood, in 1822, was the first in this century to write concerning this form of nourishing; the next writer was Steinhausen, in 1845. It is recorded, however, that an Italian physician employed this method successfully two centuries ago (Dr. Bodenhamer: "Rectal Medication"). In the discussion of this subject the topic of rectal medication will be included. In almost all cases of nourishing by the rectum it is found necessary or convenient that the nutritive material or the drugs should be either in fluid form or in suspension. (The subject of suppositories will not be discussed in this article.) In many instances rectal alimentation has been used alternately with feeding by the natural method or by the use of the stomach-tube, for a longer or shorter period; indeed it is rare to find an instance where rectal nourishing has been carried on exclusively for a great length of time.

The rectum is freely supplied with lymphatics and blood-vessels; its glandular supply is abundant, there being both the follicles of Lieberkühn and lymphoid follicles, similar to the solitary glands of the small intestine. Dr. Flint thinks that digestion and absorption may be due to the presence of the follicles of Lieberkühn, which may take on a vicarious action when stimulated by the presence of digestible material; also that the presence of food in the large intestine may stimulate the glands of the stomach and small intestine, the secretions passing into the large intestine.

Rectal alimentation has been used in the following diseases and injuries: in spasmodic constriction of the œsophagus, cancer of the œsophagus, cancer of the pylorus, ulcer of stomach, "encephaloid disease of uterus with sympathetic stomach disturbance," phthisis, anæmia, dyspepsia, pyæmic abscess and sloughing of the parotid gland, inflammation of mouth, fauces, œsophagus, and stomach due to swallowing strong ammonia water, and in lacerated wound of pharynx and trachea. The longest period during which this form of nourishment has been kept up is fifteen months (Dr. Flint in *American Practitioner*). In another case (reported by Niemeyer) this method was kept up for three months; in a case of carcinoma life was prolonged forty-two days; in several cases this method has been kept up for twenty-eight days. In most cases feeding by the stomach was resumed gradually and carried on in connection with rectal alimentation. Kauffman (*Lancet*, 1877) reports nine cases, seven of cancer of œsophagus, one of cancer of pylorus, and one of ulcer of the stomach, in which this method was used; all lived nine or more months under this treatment.

In the report of the Therapeutical Society (New York, February, 1879) there is the following analysis of sixty-three cases which were nourished by enemata of defibrinated blood: in thirty-eight cases of phthisis, eight did not bear the treatment well, ten were not benefited, twenty were benefited, one case of diarrhœa was made worse; in nine cases of anæmia, one received no benefit, eight were improved or cured; in five cases of dyspepsia all were cured; in four cases of exhaustion all were improved; in three cases of neuralgia, one was not benefited, two were improved; in two cases of gastric ulcer, one was not benefited, the other recovered when apparently moribund.

The indications for the employment of this form of alimentation may be stated as follows: Whenever from any cause it is impossible to convey food to the stomach by the natural passages; whenever the stomach is too irritable to retain food or too much diseased to digest it; whenever the presence of food in the stomach or small intestine causes trouble, or when there is great exhaustion from any cause, then rectal alimentation is clearly indicated. Except when the difficulty is obstruction of the œsophagus or disease of the stomach, this method is used in connection with feeding by the natural method.

The process of nourishing by the rectum is quite simple. The rectum is prepared for the nutrient enema by first administering an enema of lukewarm water. It is not always necessary to do this, but it should be done if there has not been a passage since the last nutrient enema, or if any portion of this has not been absorbed, although it almost always is entirely taken up. The mechanical means employed is similar to that used in giving an ordinary injection: a syringe with a screw-piston is safest, but an ordinary barrel-syringe, or Davidson's syringe, may be employed, care being taken not to use too great force. After withdrawing the tube of the syringe a towel should be pressed against the anus until the desire to void the contents of the rectum has passed away. The quantity to be injected should not exceed six ounces at a time, and this may be repeated every four or five hours; not less than three hours and not more than six should intervene between any two injections.

Various substances have been employed in this method, as raw beef, beef-soup, chicken-broth, beef-tea, defibrinated blood, milk, cream, eggs, and coffee. (Leube was of the opinion that eggs and milk were not absorbed by the rectum, but this seems to have been an error.) Liebig's

extract of meat has been used with success. In the report of the Therapeutical Society defibrinated blood is recommended for the following reasons: Patients thrive on it; in quantities from two to six ounces it is all absorbed; it causes constipation in but very few cases for a few days only; it causes no irritability of the bowels except in very few cases; it gives an impulse to nutrition, and it is wholly unattended by danger. Brown-Séquard (*Lancet*, 1878) has used the following formula: Two-thirds of a pound of raw beef, one-third of a pound of fresh pancreas; this was injected twice a day. This was followed by the passage of well-formed fæces. The fat and cellular tissue should be rejected. Kauffman, in his cases, gave one pound of finely divided beef, and one-half pound of minced pancreas every morning; half this quantity was given at noon and at night. A solid stool followed every day. The patients were able to walk about. In one case good results were obtained from the use of two teaspoonfuls of Liebig's extract in a teacupful of milk, about every four hours. Dr. J. H. Beech nourished a patient with uterine trouble and sympathetic stomach trouble for five weeks with enemata of chicken-broth, coffee and cream, beef-broth and milk and eggs; he found that coffee and cream seemed best to relieve the thirst. Dr. J. O. Davis (*Medical Record*, 1878) nourished a patient with ulcer of the stomach by lukewarm enemata of beef-tea, or chicken-broth, for six weeks. Dr. McLane nourished a patient exclusively by enemata of unsalted beef-tea for twenty-eight days, eggs and milk being resorted to only three times; a little brandy and tincture of opium (ten drops) was added to each injection. Later, feeding by the stomach was partially resumed. The patient lived one year. Dr. W. T. Chandler (*Louisville Medical News*) reported a case of ulceration of the œsophagus, from swallowing strong ammonia water, in which rectal injections of eggs and milk were the only nourishment taken for twelve days; feeding by the stomach was resumed gradually. In a case of sloughing of the parotid gland, following a pyæmic abscess, the patient, a woman, sixty-five years old, was nourished solely by enemata of beef-tea for four weeks, followed by recovery (Woman's Hospital). In a case occurring at Bellevue Hospital in 1878, a patient was nourished by enemata of eggs and milk, together with a little brandy and a few drops of the solution of morphia (U. S. Ph.). The preparation known as Leube's Pancreatic Meat Emulsion has been recommended for use in this form of alimentation. It is prepared as follows: Five to ten ounces of meat free from fat and chopped very finely; half this weight of fresh minced pancreas (of pig or ox) is added to the meat, and the whole rubbed up with five ounces of lukewarm water. When administered the enema should be tepid.

It may be mentioned here that when water cannot be administered by the stomach, thirst may be relieved by bathing the body.

In many cases it has been found necessary to overcome the irritability of the bowels by the use of some preparation of opium. In one case, from twenty to thirty drops of laudanum were added to the enema whenever it seemed necessary. Solutions of morphine have also been used successfully for this purpose.

If the necessary amount of nutriment has been conveyed to the system by this method there will be the usual feeling of comfort experienced after a meal, without, of course, the sensation of fulness in the epigastric region. Diarrhœa is very seldom caused, and the functions of the skin and kidneys do not seem to be affected. Patients not only thrive under this treatment, but actually gain in flesh and strength.

The subject of *medication by the rectum* is very closely associated with that of feeding by the rectum. In almost all cases of prolonged rectal alimentation, drugs are combined with the enemata, either for their general effect on the system or to assist in the process of nourishing. There are many cases, however, in which drugs have been administered alone. The indications for this method of medication are the same as for alimentation by the rectum; this method is especially useful in irritability of the stomach. It is quite common to add a small amount of brandy or whiskey to a nutrient enema in cases where a stimulant is needed. One writer says that in using stimulants it is well to add cream to the enema. He says, also, that tincture of the chloride of iron may be given in this vehicle. Quinine has been given in this way quite frequently. In a case of peritonitis following ovariotomy (Woman's Hospital, New York), quinine was administered in enemata to reduce the temperature; thirty grains were given in milk every four hours; the rectum became irritable after the first few injections, and this method had to be given up. Dr. Flint cites a case of violent hæmatemesis which was controlled by injecting three drachms of the fluid extract of ergot into the rectum; rectal alimentation was carried on for some time subsequently. Thirty-grain doses of chloral hydrate have been administered in this way in cases of neuralgia, in cases of acute mania, and also in the vomiting of pregnancy. The ethereal tincture of iodine has been injected in five-drop doses, and also the balsam of copaiba in two-drachm doses. In all cases it is necessary to add a vehicle in sufficient quantity to make about a four-ounce mixture.

The use of simple enemata of warm water or warm water and soap, to cause an evacuation of the bowels, is of such common occurrence in domestic practice that it is hardly necessary to speak of it here. Several medicines, as castor-oil, oil of turpentine, and assafœtida, may be added to these simple enemata.

William H. Murray.

ALKALIES. The alkalies are inorganic substances, possessed usually of a caustic "alkaline" taste, which unite readily with acids to form salts. They will restore the blue color to litmus paper reddened with acids, turn syrup of violets and red cabbage infusion green, and turmeric yellow a reddish brown. Properly speaking, only those substances answering to the above description, whose carbonates are soluble in water, are called alkalies, viz., ammonia, lithia, potassa, and soda; but in medicine two of the alkaline earths, lime and magnesia, are also included under this term. The carbonates of these substances possess many properties in common with their bases, and exert a similar therapeutical action when internally administered. The acetates, citrates, and tartrates resemble in their remote effects the carbonates, and may therefore for our present purposes be classed among the alkalies.

EXTERNAL USES.—Potassa, soda, and lime, when applied in concentrated form, are powerful escharotics. Potassa is the strongest and is the one to be preferred when extensive and complete destruction of tissue is desired. It penetrates deeply and widely, and the skin about the part to be destroyed should therefore be protected by cerate or a ring of adhesive plaster. It is employed to destroy malignant pustule, epithelioma, and other morbid growths, to establish healthy action in sloughing and phagedenic ulcers, and to cauterize the bites of reptiles and rabid animals, and other poisoned wounds. It was formerly used also to open abscesses or cysts of the liver. Its action causes intense pain, and the slough formed is of a dirty grayish color. When the destructive action has proceeded as far as desirable, it may be arrested by washing the parts with vinegar or some other dilute acid. Caustic potash abstracts the fluids from the tissues, and, uniting with them, forms a liquid which exerts an escharotic action wherever it may flow. In order to absorb this fluid, and thus limit the extent of the caustic action, an equal quantity of unslaked lime is added to the potash and formed into a paste with alcohol. This is the well-known Vienna paste. Caustic soda is milder than potassa, and is seldom used as an escharotic. A mixture of soda and lime, rubbed up with alcohol into a consistent mass, is called London paste. It is employed for the same purposes and in the same way as Vienna paste, than which it is milder. Alkaline lotions are used to allay itching, as an application in various skin affections, and to correct the fetor of bromidrosis. Liquor potassæ, or a solution of the carbonate of potash, is generally selected for this

purpose. Liquor potassæ is also used to soften the edges of the nail in ingrowing toe-nail. Bicarbonate of soda is one of the best applications for burns and scalds of the integument; in burns of the first or second degree its immediate application in strong solution will almost instantly relieve the pain and prevent inflammation. This is a remedy superior to the mixture of lime-water and linseed oil, known as carron oil. Ammonia is much employed as a rubefacient and counter-irritant, in the form of liniment. If strong aqua ammoniæ be applied to the skin and covered by a glass to prevent evaporation, vesication is produced. It is used likewise in the bites of venomous reptiles, because of its repute as an antidote to snake-poison, but the better plan is, when possible, to thoroughly destroy the parts with potassa or the actual cautery. The irritation resulting from the bites of insects is relieved by ammonia. Solutions of the lithia salts are sometimes applied to the affected joints in chronic rheumatic arthritis.

INTERNAL USES.—Potassa and its salts, when given in large doses, act as cardiac depressants and paralyzers of the spinal cord. In medicinal doses the acetate and citrate increase the quantity of urine, and render this secretion alkaline. For the former purpose the acetate is to be preferred, and for the latter the citrate. Liquor potassæ in small dose, given before meals, stimulates the secretion of the gastric juice, and thus promotes digestion. Given after meals it neutralizes an excess of acid in the stomach, but magnesia and bicarbonate of soda are preferable as antacids. The former is also a laxative, and is to be selected when the action of the bowels is sluggish. When the opposite condition prevails, carbonate of lime or chalk may be prescribed with advantage. It is especially in the acid diarrhœa of infants that chalk mixture is valuable. Lime-water relieves gastrodynia and vomiting, and is added to milk to prevent the formation of caseous masses in the stomach. The treatment of rheumatism by alkalies was formerly much in vogue, but these are now generally superseded by other more efficacious remedies. The alkalies promote the absorption of fat and induce anæmia, and hence they leave the patient in a weakened condition after the rheumatism has been cured, and convalescence is thereby unnecessarily prolonged. When alkalies are to be used, the lithia salts should by preference be selected. Ammonia is a diffusible stimulant, and is seldom employed as an antacid. The carbonate and muriate are excellent stimulant expectorants, and are very frequently given in bronchitis and in the resolving stage of pneumonia. In cases of sudden and profound depression the intravenous injection of ammonia has answered an excellent purpose. Ammonia is also given internally as an antidote to snake poisons, but its efficacy in this respect is doubtful. *Thomas L. Stedman.*

ALKALINITY. Oxidation of organic substances in the human economy, as in the chemical laboratory, occurs best in alkaline media. Many organic substances require the presence of alkalies to render them oxidizable at the body temperature. Thus alcohol, in the presence of a free alkali, is easily burned up at body heat, and glycerine, ordinarily resistant to such influences, will readily be oxidized. Life, which is dependent upon a constant succession of oxidation processes, takes advantage of this fact by maintaining that menstruum (the blood) in which its important chemical changes occur, in a constantly alkaline condition. No indubitable examples of acidity of the same have ever been recorded as existing during life; though some cases of leucocythæmia, sunstroke, and cholera have been reported, in which, soon after death, the blood was feebly acid. Moreover, attempts to render it acid have signally failed, death occurring before such a condition could be induced. Witness the experiments of Hoffman, who, in attempting to render the blood of pigeons acid by the administration of foods yielding acid oxidation products, induced toxæmia before acidity (of the blood). Besides favoring oxidation processes, the alkaline salts aid in maintaining the albuminoids in a soluble condition, and increase the power of absorption for gases of the blood-serum. The amount of alkaline matter in the blood is comparatively constant, though subject to slight fluctuations.

The blood owes its alkalinity chiefly to the sodic bicarbonate ($NaHCO_3$) and sodic phosphate (Na_2HPO_4), though partly, too, to the alkaline albuminates. In health its reaction is subject to variations intimately dependent upon the digestive processes; the chemical nature of the foods taken determining the extent of change. During the absorption of the foods there are always being taken into the circulation organic salts of the alkaline bases, and often small quantities of the alkaline phosphates. The former, in the presence of ozone and an alkaline serum, are easily converted into the alkaline bicarbonates. Hence increased alkalinity of the blood. This is the more marked when the organic salts have been introduced either incidentally to the preparation of the foods, or for medicinal purposes. Thus the "saleratus," "cooking soda," and "baking powders" now so extensively used to lighten our breads, biscuits, cakes, and pastries, by their liberation of CO_2, are converted at the same time into organic salts (acetates, lactates, or tartrates), which, on entering the circulation, are burned up into the alkaline bicarbonates with distinct effect upon the blood reaction. Or again, the so-called "lemon" treatment, when it is desired to induce an increased alkalinity, is thoroughly scientific. The lemon-juice, which already contains potassium and calcium citrates, being added in large excess to a small quantity of sodium bicarbonate, converts the latter into a citrate, at the same time making a pleasantly acid effervescent drink. This, on being absorbed, increases the blood alkalinity, as do the other organic salts. It is just to this absorption and conversion of organic salts that the daily changes in the urine reaction are due. Just before the meal hour the urine (in health really an index of the alkalinity of the blood) reaches its maximum acidity; at the same time the blood is least alkaline. In a short while, when absorption and conversion of the organic salts has begun, its alkalinity steadily increases, until finally (particularly after the consumption of the "soda-raised" foods) the urine becomes neutral, or even distinctly alkaline, from the excretion of the excess of alkaline matter. When the organic salts have been converted into bicarbonates, and the excess has been excreted through the urine, the latter begins again to resume its normally acid reaction from the oxidation products of the nitrogenous tissues chiefly.

It is not probable that, as some authors suggest, the normal alkalinity is maintained by the excretion of excess of alkaline matter by the salivary, biliary, and pancreatic glands, and excess of acids by the gastric follicles; because it has been repeatedly demonstrated that when one secretion withdraws from the blood acid matter, other secretions increase decidedly their alkaline constituents. Thus the withdrawal from the blood of alkaline and acid matter at the same time would not alter its relative alkalinity. When the stomach is pouring out its acid secretion, the salivary, biliary, and pancreatic secretions become unusually alkaline. The kidneys, assisted by the lungs and integument, serve as the chief exits for the excess of alkalies or acids from the blood.

Lewis L. McArthur.

ALKANET (*Orcanette*, Codex Med.; *Alkanna tinctoria* Tausch.; *Anchusa tinctoria* L.; *Lithospermum tinctorium* D. C., etc.; order, *Borraginaceæ*) is a small perennial hairy herb, with straggling forked stems, simple spatulate or lanceolate leaves, and one-sided cymes of tubular, nearly regular flowers. It is a native of the southern and eastern part of Europe and Asia Minor, and is also cultivated.

The fleshy root, which is the part employed, is one or two centimetres (two-fifths to four-fifths of an inch) in diameter, branched above into several stem-bearing heads, usually simple below, soft and stringy in texture. The dried root of commerce is sometimes entire, with a purplish-red external surface, a soft, easily separable and exfoliating bark. It is of a dull, deep red color within, and has a pinkish or whitish, hard, but easily-splitting wood. More often the roots are twisted and incom-

pletely split into coarse shreds; in the better grades, the woody cylinder is removed, and they consist of the tough and flexible bark.

Alkanet has no odor, but a sweetish, afterward bitterish and slightly astringent taste, coloring the saliva when chewed.

Its only valuable constituent is its coloring matter, alkannin, or alkanna red, which was first separated by Pelletier, and named *acide anchusique*. To obtain it, the root, first treated with water, is exhausted by slightly acidulated alcohol, the tincture so obtained is evaporated to a thickish, turbid extract, and the alkannin precipitated with water. It is then re-dissolved in ether, the ether mostly washed out by shaking with successive portions of water, and, finally, the thick solution evaporated to dryness (Huseman, Balley, and Wydler, "Ann. Chem. Pharm.," 141).

It is a dark brownish-red, resinous mass, or powder, insoluble in water, but soluble in the liquids above named; neutral in reaction. Its red color is intensified by acids, and changed to bluish-green by alkalies.

Alkanet has no physiological action and no medical use. It is, however, used in elegant pharmacy to color oils, cerates ("rose lip-salve"), and tinctures, and occasionally in making test-papers which may be prepared either red or blue.

Allied Plants.—The order *Borraginaceæ* comprises a number of bland, hairy herbs with no distinctive medicinal qualities. (See Borage.)

Allied Drugs.—For a list of the pharmaceutical coloring matters see Saffron.

W. P. Bolles.

ALKEKENGI (*Alkekengi coqueret*, Codex Med.; *Physalis alkekengi* L.; order, *Solanaceæ;* ground plum). This little genus of annual or perennial, spreading, sometimes prostrate, herbs differs but little, botanically, from *Solanum* or *Lycopersicum* (the tomato) excepting that the calyx loosely envelops the fruit in a miniature, usually five-angled papery, balloon-like bag. One species, with fragrant yellow edible fruit, is cultivated in this country, now and then, under the name of "strawberry tomato." *Physalis alkekengi* is a perennial weed of Central and Southern Europe, bearing a round, shining scarlet-red berry, about as big as a cherry, enclosed in its calyx-bag, four or five times as large. The fruit is two-celled, with numerous kidney-shaped, flat seeds embedded in a fleshy, pulpy pericarp; odorless, with mawkish sweet taste, sometimes bitter, and, dried, forms the commercial drug. It is then brownish red, much shrunken, and generally bitterish. It is reputed to be diuretic and laxative, and is an ingredient of some European preparations, but is not entitled to rank as a medicine. The berries are also pickled and eaten.

The calyx, which is not used, contains an abundant bitter principle, which has been named *physalin*.

For allied plants and drugs see Belladonna.

W. P. Bolles.

ALLANTOIS. In this article is given an account only of the origin and morphology of the allantois; for its metamorphoses and functions see Placenta. The allantois is a hollow outgrowth from the ventral wall of the posterior extremity of the digestive canal; morphologically, it is a modification of the bladder, lasting till the end of fœtal life. The bladder appeared early in the evolution of vertebrates, being constant in the amphibia and all higher forms. In the fœtus of all reptiles, birds, and mammals the bladder is modified by being greatly enlarged and projecting beyond the body proper, so as to be a true appendage, the allantois, the possession of which distinguishes the embryos of the three classes named. The same classes also have an amnion, a structure not found in the lower vertebrates. The terms *allantoidea* and *amniota* are therefore strictly synonymous and both include the three higher classes of vertebrates. In tracing the origin of the allantois we find a remarkable illustration of change of function; the organ which appears first as a urinary vesicle is precociously developed and enormously enlarged in the embryo; and has acquired respiratory functions in the reptiles and birds, and later nutritive functions in the mammalia. In accordance with its new duties the vesicle is furnished with a greatly increased vascular apparatus. The aorta forks at its caudal extremity, and each fork again divides; one branch goes to the leg (iliac artery) and one branch runs up along the side of the bladder and ramifies upon its outer portion; the main stem is known as the hypogastric artery. The blood is collected from the allantois by two veins (umbilical or, better, *allantoic*); in man and other mammals, however, one of these veins, the right, early disappears, so that during most of the fœtal life there is only one vein, the left.

The exact origin and growth of the allantois in the embryo can be understood only in connection with the history of the germ-layers, and is treated of under Fœtus. In form the allantois varies greatly; in birds and reptiles it is a large sac which protrudes from the abdomen; in the higher (placental) mammals this sac is still further modified to constitute the essential part of the placenta; indeed the placenta may be best defined as an allantois so specialized as to establish a direct nutritive relation between the mother and offspring.

The following brief account will suffice to elucidate the comparative morphology of the allantois. It will be remembered that during the very early stages of the embryo, the body cavity is not closed but open; the external abdominal walls (somatopleure) extend down for a short distance, and then bend outward and upward on all sides so as to completely arch over the back of the embryo; that part of the somatopleure which thus encloses the embryo is a thin membrane, long known as the amnion. On the other hand, the walls of the intestinal canal (splanchnopleure) likewise extend beyond the embryo, making a contracted stalk at the end of which is the yolk-sac. These relations are shown in the accompanying diagram.

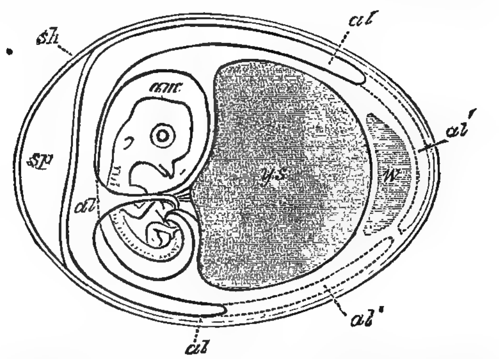

Fig. 74.—Diagram of a Young Allantoidean Embryo Chick. *sh*, calcareous egg-shell; *sp*, air-space; *am*, amniotic cavity; *ys*, yolk-sac or umbilical vesicle; *w*, remnant of the white of the egg; *al*, allantois; *al'*, dotted lines representing the later nearly maximum extension of the allantois.

It will be observed that the body-cavity is continuous with a large space around the embryo, lying entirely outside the closed amnion and inside the chorion. Into this space grows out the allantois, appearing first as a small diverticulum, but rapidly enlarging to an ample vesicle. As the embryo grows the yolk-sac, except when modified as a secondary respiratory organ (rabbit, etc.), diminishes while the allantois enlarges still more rapidly, and thus soon becomes the principal appendage of the embryo. In this stage it is readily identified in birds and reptiles; the actual relations are well indicated by the admirable diagram here given of a hen's egg after about ten days' incubation; the figure is copied from Allen Thompson. If the walls of the vesicular allantois be examined, they are found to consist of two layers, 1, a stratum of epithelium which is directly continuous with the epithelium of the digestive tract, and therefore represents the innermost germ-layer or entoderm; 2, a stratum of connective-tissue (so-called mucus) cells lying externally and representing the middle germ-layer or

mesoderm. Now the placenta of mammals is formed mainly by the developments which take place in the outer (mesodermic) layer of the allantois. There arise, namely, irregular outgrowths or villosities, richly supplied with blood-vessels; these force up the chorion and so project beyond the general surface of the ovum; the projecting villi fastened by their tips to the irregular surface of the uterine wall. This combination of fœtal and maternal tissues constitutes the placenta. In the majority of mammals the allantois retains its vesicular character; the various classes are distinguished from one another by the form and distribution of the villi over the allantois. They are *diffusely* scattered in the horse, pig, etc.; in the ruminants they are collected into patches or *cotyledons;* in the carnivora and elephants they are gathered into a distinct *zone;* in the rabbit they are restricted to a circular *disk.* In man still further modifications occur; the cavity of the allantois remains always exceedingly small, and the epithelial lining is, of course, correspondingly reduced; the mesodermic layer, on the contrary, undergoes an excessive enlargement and produces a circular villous area, which enters into the formation of the placenta; the term *metadiscoidal* is employed to distinguish the human placenta from the *discoidal* of the rabbit.

For the early history of the human allantois, which is in reality quite unlike that of the bird, see Fœtus, Development of; for the details of its structure and connection with the uterine wall, see Placenta; for a statement of the manner in which it is enclosed to form part of the umbilical cord, see Amnion; compare also Umbilical Cord.

Charles Sedgwick Minot.

ALLEGHANY SPRINGS. *Location and Post-Office,* Alleghany Springs, Montgomery County, Va. Three and one-half miles from Shawville station, on the Norfolk & Western Railroad, and about eighty miles west of Lynchburg. The geological character of the neighborhood is "magnesian limestone of the lower silurian period, intercalated with argillaceous slates of the same age." The spring at present in use is a moderately-flowing one, discharging about four hundred gallons per day. As analyzed by Dr. F. A. Genth, the composition and general character of the water are as follows: Limpid; temperature, 53° F.; taste, slightly alkaline, but pleasant; faint acid reaction, when fresh, from free and partially combined CO_2. On standing, the water deposits a small quantity of lime carbonate, magnesium carbonate, and minute traces of silicic acid, aluminium silicate and phosphate, etc.—in all about 4.704 grains to the gallon.

Analysis.—One gallon (70,000 grains) contains:

	Grains.
Sulphate of magnesia	50.884290
Sulphate of lime	115.294022
Sulphate of soda	1.717959
Sulphate of potassa	3.699081
Carbonate of copper	0.000359
Carbonate of lead	0.000569
Carbonate of zinc	0.001713
Carbonate of iron	0.157049
Carbonate of manganese	0.060617
Carbonate of lime	3.613209
Carbonate of magnesia	0.362362
Carbonate of strontia	0.060536
Carbonate of baryta	0.022404
Carbonate of lithia	0.001679
Nitrate of magnesia	3.219562
Nitrate of ammonia	0.559412
Phosphate of alumina	0.025549
Silicate of alumina	0.207399
Fluoride of calcium	0.022858
Chloride of sodium	0.274676
Silicic acid	0.882782
Crenic acid	0.001921
Apocrenic acid	0.000192
Other organic matter	1.999121
Carbonate of cobalt, Teroxide of antimony,	Traces.
	183.069321
[Solid ingredients by direct evaporation gave 184.072000.]	
Half-combined carbonic acid	1.885526
Free carbonic acid	5.455726
Hydro-sulphuric acid	0.001339
Total amount of ingredients	190.411912

Therapeutic Properties.—The presence, as in this water, of both the lime and magnesium sulphates is very unusual, and especially in such large proportions. As regards the effect upon the bowels it would be imagined that these two ingredients would counteract each other, and such, to some extent, is the fact. Taken in large quantities the water is purgative and diuretic, but in smaller doses the effect is tonic. The reputation of the spring is firmly established as of great efficacy in many forms of digestive disorders, those especially associated with chronic diarrhœa, constipation, and torpid liver. It is doubtful whether any of the other numerous ingredients are of any medicinal value.

The accommodations for guests are upon a liberal scale, and consist of a large and well-appointed hotel, and about one hundred and fifty outlying double cabins or cottages. Pure spring water is freely distributed, being brought from the mountains through pipes, thus affording hot and cold bathing in every part of the establishment. The ordinary drinking water is of two kinds—limestone and freestone. There are churches and school accommodations on the grounds.

Situated on the eastern slope of the Alleghanies, the highest point between the eastern seaboard and the Rocky Mountains, and on the headwaters of the Roanoke River, these famous springs offer unusual attractions in point of scenery and healthful climate.

Geo. B. Fowler.

ALLEVARD, a watering-place in the Department of Isère, France, near the border of Savoy; latitude, 45° 24′ N.; altitude, 475 metres (1,558 feet). From Lyons it may be reached by taking the railway as far as Montmélian, and then driving a distance of twenty-four kilometres (about fifteen miles). The town is situated in one of the most beautiful valleys of that region, which is also celebrated for the wine which it produces. The climate, however, is very variable. There is but one spring, whose copious waters have a temperature of 24.3° C. (76° F.). Several analyses of the water have been made, but their results—in harmony with the varying composition of the water itself—vary so considerably that no reliance can be placed on any one of them. This, however, is not an uncommon experience in saline springs containing an abundance of earthy matter. There were found from twelve to twenty-two parts of solids in ten thousand parts of water, magnesium and sodium sulphate furnishing the largest proportion. A little iodine was also found. Of the gases, hydrogen sulphide is the most prominent, and is indeed present in large amount, perhaps to the extent of 0.21 in ten thousand parts by weight. The water is taken at the spring at its natural temperature. Patients suffering from chronic pulmonary and bronchial affections drink it heated to 36° C. (96.6° F.). Taken in small doses, the water seems to produce no appreciable effects, but in large draughts it is a powerful circulatory stimulant. Aside from the use of the water as a beverage, it is employed in the form of baths, and particularly is it advisable to use these in combination with whey, at a temperature of 36° C. (96.6° F.). The proportion of whey to water should be as three to two. In this way a powerful tonic and sedative effect is produced, which forms an important element in the course of treatment. In the bathing establishment there are seven large inhalation chambers, in which the temperature is of a pleasant degree of coolness. Then there are, in addition, two inhalation-rooms of various degrees of saturation with watery vapor and hydrogen sulphide, heated to a temperature of from 80° to 83° F. The air in these may contain hydrogen sulphide in the proportion of one to one hundred thousand parts. The effect of inhaling the air in the large cool chambers is at first, in the case of a healthy person, somewhat soothing, but after a time it begins to produce some excitement of the respiration and of the heart's action, which, however, is soon succeeded by a period of comparative quiet. A protracted stay in the inhalation-chamber may produce serious symptoms, such as bronchial irritation, a condition suggesting intoxication, pain in the stomach, loss of appetite,

persistent constipation, or a diarrhœa characterized by black stools, disturbed sleep, etc. The treatment should therefore be pursued under the guidance and advice of a physician who is familiar with the methods of the establishment and with the effects to be expected in different diseases. Beneficial effects may be expected from the inhalations in cases of simple bronchitis, in the bronchial catarrhs of old people, in bronchial catarrh associated with emphysema, in nervous cough, in asthma (except during the paroxysms), in simple laryngitis, and in chronic pleuro-pneumonia. In cases of herpes, rheumatism, gout, and pulmonary tuberculosis, the water should be administered internally and in the form of baths, as well as by inhalations. In diseases of the skin, generally, the baths of Allevard will be found to be too irritating. *Henry Fleischner.*

ALLSPICE (*Pimenta,* U. S. Ph.; *Pimenta officinalis* Lindley; *Eugenia Pimenta,* D. C.; order, *Myrtaceæ*), whose unripe fruits constitute "allspice," is a handsome, evergreen, fragrant tree, about ten metres (thirty feet) in height, with opposite dark-green, shining leaves, and small white flowers. The leaves are oval, with tapering bases, thick, coriaceous, and punctated, like the others of the family, with semi-transparent dots, indicating oil-glands in their substance. The flowers are in axillary cymes near the ends of the branches—tetramerous, with numerous stamens and a two-celled inferior ovary. The fruit is a rather dry, stony berry, from one-half to one centimetre (one-fifth to two-fifths inch) in diameter, nearly spherical and crowned with its four-parted calyx and short cylindrical style.

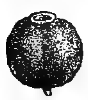

FIG. 75.—Pimenta Officinalis, Fruit (entire).

The allspice tree is a native of the West Indies, South and Central America, and Mexico. It is abundant in the island of Jamaica, both wild and cultivated, and has been introduced into Asia and other tropical places.

This spice has been used in Europe for more than two centuries, and is still in great demand, both there and here, as a domestic condiment. It comes almost entirely from Jamaica, where it is obtained in enormous quantities from both wild and cultivated trees. The fruits—like those of pepper and cubebs—are collected just before they are ripe and dried in the open air. When fully ripe a portion of the fragrance is lost. The dried fruits are slightly smaller than the fresh, round or nearly so, finely wrinkled or tuberculated upon the surface, of a brown or grayish-brown color, and having a strong, agreeable, aromatic, clove-like odor. The limb of the calyx is usually rubbed away, leaving a circular projecting margin, or crown, at the apex of the fruit, enclosing a shallow, saucer-shaped calyx cup, from the middle of which rises the style, usually broken off at the top. They are two-celled and two-seeded (sometimes one-seeded by suppression). Seeds brown, flattish, exalbuminous; embryo spirally coiled. A section of the fruit reveals, just below the surface, numerous large oil-cells, some of which projecting outward form the small corrugations to be seen upon the outside. These cells contain most of the oil; in the seeds are also fewer and smaller oil-cells.

FIG. 76.—Longitudinal section of same (enlarged).

The oil of allspice (*Oleum Pimentæ,* U. S. Ph., Br. Ph.), which is its only valuable constituent, can be obtained to the extent of two to four per cent. It is a heavy, yellow, thickish essential oil, having the odor and taste of its source; specific gravity, 1.037. It consists of two parts, one lighter than water, a hydrocarbon, and one heavier, probably Eugenol, the same as in oil of cloves.

ACTION AND USE.—Similar to that of other aromatics. (See Cloves.) Not often used as a medicine, occasionally as an adjuvant, probably inferior to cubebs for the special purposes for which they are used; as a stomachic the choice between allspice, cinnamon, and cloves is merely a matter of taste, all being equally good. Allspice is not often taken in substance, but might be if desired. A dozen berries or a gramme (gr. xv.) of the powder would be slightly stimulant to the stomach. The oil is to be preferred and might be given in doses of from two to four centigrammes (♏ iij. ad vj.).

It is an ingredient in the officinal bay rum (*Spiritus Myrciæ,* U. S. Ph.), and *Syrupus Rhami* (Br. Ph.), also there is an *Aqua Pimentæ* (Br. Ph.). For allied plants and allied drugs, see Cloves. *W. P. Bolles.*

ALMONDS, BITTER AND SWEET (*Prunus Amygdalus* H. Bn.; *Amygdalus communis* Linn.; order, *Rosaceæ, Pruneæ*). The almond tree is a small, graceful tree, inhabiting the countries bordering the Mediterranean Sea, Greece, Asia Minor, Syria, Algeria, as well as Abyssinia and other Eastern lands. It has been cultivated also in many of these places from time immemorial. It is very similar in size and appearance, as well as leaf and flower, to its near ally, the peach, growing from five to ten metres in height (sixteen to thirty-two feet), with graceful branching top. The leaves are oblong, lanceolate, finely serrated, simple, and give when bruised a peachy odor. The flowers are large, pale-rose colored, almost exact counterparts of those of the peach. But the fruit, although structurally similar, develops differently; that part (the sarcocarp) which in the peach becomes juicy and edible, in the almond dries up, splits, and falls away, leaving the stone (putamen) attached to the tree. This is then gathered and makes the almond of commerce.

FIG. 77.—Prunus Amygdalus, Leaves and Bud.

It is an oblong ovate, pointed, yellow "nut," somewhat flattened, with blunt or sharpish borders, and a roughish surface, perforated with numerous pores and depressions. The shell is variable, usually hard enough to require a light hammer to break it; in some varieties easily crushed between the thumb and forefinger. The seed is sometimes, in some varieties always, imported without the shell. It is solitary and exalbuminous.

Long cultivation has produced many horticultural varieties of almonds, depending mostly upon their size, shape, and thickness of shell; but the most important distinction is that of taste and composition, in respect to which these varieties fall into one or another of two series, namely, those with bitter, and those with sweet or bland seeds. The trees producing them do not differ from each other much, excepting in the character of the seeds, but yet appear to be distinct, both existing in the wild state.

FIG. 78.—Prunus Amygdalus, Flowers.

1. *Prunus Amygdalus amara* Benth. and Hook (*Amygdalus communis amara* L.) grows wild and is cultivated in the localities given above, but is more especially cultivated in Northern Africa and the Mediterranean Islands, the rather small Barbary almonds being preferred. This variety yields:

Bitter Almonds (*Amygdala Amara,* U.S. Ph., Br. Ph.; *Amygdalæ amaræ,* Ph. G.; *Amandes amères,* Codex Med., etc.). They are smaller and thicker than some kinds of sweet almonds, but are of several sorts themselves, and vary. They are thus described: "About one inch (twenty-five millimetres) long, oblong lanceolate, flattish, covered with a cinnamon brown scurvy testa, marked by about sixteen lines, emanating from a broad scar at

the blunt end. The embryo has the shape of the seed, is white, oily, consists of two plano-convex cotyledons, and a short radicle at the pointed end; has a bitter taste, and when triturated with water, yields a milk-white emulsion, which emits an odor of hydrocyanic acid" (U. S. Ph.). A magnified section of the seed shows the scurviness of the surface to be due to a layer of large projecting blunt hairs, easily broken away; the embryo consists of parenchymatous tissue, with occasional vascular bundles, the former filled with aleurone and other albuminous granules and drops of oil.

The most abundant constituent of almond, whether bitter or sweet, is the *fixed oil*, which is the same in both (*Oleum amygdalæ expressum*, U. S. Ph.), although usually for commercial reasons obtained from the former, in which it is present in from forty to forty-five per cent., by subjecting the seeds, after being ground and gently warmed, to high pressure. It is a pale yellow or almost white limpid oil, with slight, if any, odor, and a bland, pleasant, nutty taste, recalling that of almonds. It consists of nearly pure olein, and does not congeal until cooled to a point below zero. Keeps pretty well, but finally becomes rancid. Almond oil has no medicinal properties, but is adapted to any use where a simple liquid fat is desired. According to Hager ("Pharmaceutische Praxis"), the oil expressed from bitter almonds is not so good and does not keep so well as that of the sweet. Moreover the commercial oil is largely expressed from the so-called "peach-meats," as well as the seeds of other *Pruni*.

The most interesting constituent, although less abundant, in bitter almonds, is amygdalin, a remarkable crystalline glucoside contained in them to the extent of from one and a half to three per cent. It was discovered in 1830 by Robiquet and Boutron Charlard, and its peculiar decomposition in 1835 by Wöhler and Liebig. Amygdalin may be prepared by exhausting the cake left after pressing out the fixed oil, with boiling alcohol, evaporating and precipitating with ether, washing the impure precipitate again with ether, and then crystallizing it from boiling alcohol. It is in fine pearly scales, or larger transparent, colorless, orthorhombic prisms, according to the amount of water of crystallization contained. Soluble in twelve parts of water at ordinary temperatures, and in all proportions of boiling water. Nearly insoluble in cold, but freely soluble in boiling alcohol. Ether does not dissolve it at all. Its taste is intensely and purely bitter; it has no odor, and *alone* is not poisonous, and probably a simple bitter tonic; as much as four grammes (ʒ j. +) having been taken at one dose with impunity. Half-gramme (gr. xxxj.) doses, three times a day, have been continued without ill effects, but once an odor of prussic acid was noticed in the eructations.

Besides the above substance, bitter almonds also contain, in common with sweet almonds, an uncrystallizable albuminoid ferment, *emulsin*, which exerts a peculiar power over amygdalin. This was discovered by Wöhler and Liebig in 1835, and is prepared by a rather complicated process of treating sweet almonds with water, separating the other albuminous substances in the solution by acetic acid, acetate of lead, or fermentation, and finally precipitating the emulsin. It is an amorphous, whitish or pinkish powder, by no means chemically pure, as it contains at least one-third of its weight of ash, insoluble in alcohol, freely so in water, from which a portion is separated upon boiling, both portions thereby losing their power. It is closely related to the casein and albumen of the almonds, of which it is probably a modification, is not poisonous of itself, but it has the property of determining the disintegration of the amygdalin under certain circumstances. If solutions of each of these substances in water are made, and one poured into the other, after a few seconds the odor and taste of the mixture is altered and the presence of *prussic acid* and *benzaldehyd* (oil of bitter almonds) is easily proved, while the amygdalin has disappeared; with the addition of two equivalents of water it has been completely resolved into the above-named substances and glucose. The emulsin is not decomposed, but, in common with other ferments, there appears to be a limit to the amount of change it can produce. The same reaction takes place in the bitter almond seeds whenever they are ground and moistened. Advantage is taken of this reaction in the preparation of the commercial oil of bitter almonds (*Oleum Amygdalæ Amaræ*, U. S. Ph.). The mash left after expressing the fixed oil is reground, moistened and macerated to decompose the amygdalin, then distilled from water after the manner used in the extraction of volatile oils. The benzaldehyd and prussic acid, which together constitute the "oil," pass over and are condensed. It is a colorless, or light yellow, thin, volatile liquid, having a "peach-meat" odor, distinct from, but recalling that of prussic acid, and a sharp, burning taste. Specific gravity, 1.050 to 1.060. It is soluble in alcohol and ether in all proportions, and in 300 parts of water; on long standing it deposits crystals of benzoic acid. It must not, in consequence of its name, be associated with the numerous hydrocarbons and their allies, which constitute most of our aromatic stimulants, and with which it has neither chemical nor therapeutic affinity. In its ordinary state it is a preparation of prussic acid, and should only be used with that fact in mind. It is not difficult to separate the acid from the oil, and the latter when so freed has a pleasanter, purer odor, and may be used freely as a flavor; indeed, it is largely so prepared for culinary and confectionery uses.

2. *Sweet Almonds* (*Amygdala Dulcis*, U. S. Ph.; Br. Ph., *Amygdalæ dulces*, Ph. G.; *Amandes douces*, Codex Med.). The treatment of bitter almonds leaves little to be said of these. They are often larger and longer than the preceding, but cannot be distinguished from them by the eye alone. They have a sweet, bland, oily taste, free from bitterness or odor. Their composition resembles the others in most particulars; they contain the same *fixed oil* in slightly larger proportion (up to fifty per cent.), *emulsin* also in larger proportion, similar albuminoids, but *no amygdalin*. As the amount of emulsin in bitter almonds is not quite enough to fully decompose the amygdalin, it is usual, in its manufacture, to mix in some sweet almond seeds.

ACTION AND USES.—Sweet almonds have no physiological action beyond that of an oily, agreeable, rather indigestible food, and are only used for two officinal preparations, whose office is that of agreeable vehicles.

1. *Mistura Amygdalæ*, U. S. Ph.; strength $\frac{1}{16}$. Almond mixture is an emulsion made by rubbing six parts of almond with one of gum arabic and three of sugar into one hundred parts of water. It is a white, opaque, milk-like liquid, with sweetish taste and nutty flavor. It may be used freely internally or as a lotion, but does not keep well, and should be freshly made. It is pharmaceutically incompatible with acids and alcohol, which will curdle it. A few bitter almonds may be added in making, for the sake of flavor.

2. *Syrupus Amygdalæ*, U. S. Ph. (Syrup of Almonds, Syrup of Orgeat); strength $\frac{1}{10}$ sweet, and $\frac{3}{100}$ bitter (sweet almonds, 10; bitter almonds, 3; sugar, 50; orange flower water, 5; water enough to make 100). A thicker, sweeter, and more elegant vehicle than the preceding; useful in cough and antispasmodic mixtures.

The *expressed oil* (see above) is an ingredient in "cold cream" (*Unguentum Aquæ Rosæ*, U. S. Ph.), of which it comprises one-half; the other ingredients being, spermaceti, 10; wax, 10; rosewater (from which it takes its name), 30. A pleasant, cooling, unirritating, widely-used, cosmetic ointment.

The *essential oil* (see above) is used in the preparation of bitter almond water (*Aqua Amygdalæ Amaræ*, U.S.Ph.), of which it comprises the one-thousandth part. *Dose* of the oil, fifteen to sixty milligrammes (0.015 to 0.060 grm. = gr. ¼ to j.) This would allow for an active dose of the water from fifteen to sixty grammes (15 to 60 c.c. = ʒ iijss. to ℥ ij.), but it is in fact only used as a flavor, and should be restricted to this, as there is a distilled water in the market often much stronger; from five to ten or twelve grammes (ʒ j. to ʒ iij.) is as much as it is safe to give. The action of the oil in full doses is that of prussic acid, which see.

BOTANICAL RELATIONS.—The order *Rosaceæ* is so large, and its members have such disconnected qualities, that it will be most instructive to study its different tribes separately. (See Rose, etc.) The tribe *Pruneæ* is a well-marked division, comprising *Rosaceæ* with solitary free carpels, containing a one-seeded drupe. The principal genus is *Prunus*, with eighty-three species scattered over the north temperate zone. Several species are cultivated for ornament, and many for their edible fruits, which have been much improved by cultivation. A strong bitter almond flavor pervades the genus, especially in leaves, bark, and seeds, which are often used. They occasionally poison cattle. A gum consisting of almost pure bassorin (cherry-tree gum) exudes from the bark of a few species. Aside from the hydrocyanic possibilities the gum is not poisonous.

In its present extended limits, Prunus includes at least five old genera of familiar domestic plants, as follows:

1. Sub-genus *Amygdalus.*—Drupe with velvety surface, stone rough pitted; sarcocarp hard, leaves conduplicate in the bud. Ten species, including the almonds and *Prunus nana* Jess., a European and Eastern almond, yielding the so-called "peach-meats," which are extensively used in making the almond oils. Europe and Asia.

2. Sub-genus *Armeniaca.*—Fruit velvety, fleshy; vernation convolute; peaches and apricots, species two—one Asia, one America.

3. Sub-genus *Prunus.*—Fruit smooth, often glaucous; seed oblong, compressed; vernation convolute; species twenty, widely distributed. Plums, etc.

4. Sub-genus *Cerasus.*—Fruit smooth, rounder; vernation conduplicate; twenty species, widely distributed. Cherries, etc.

5. Sub-genus *Laurocerasus.*—Flowers in racemes; fruit smaller, oblong, or globose; stone smooth or rough; vernation conduplicate; thirty species; temperate and tropical regions. Cherry laurels. (See also Cherry, Wild, and Prune.)

MEDICAL RELATIONS.—Amygdalin, or something having the same power of producing prussic acid, exists in minute quantity in a number of neighboring genera of tribes *Pomeæ* and *Spiræa*, as well as in the widely different *Janipha manihot*, or cassava plant. For characters and action of prussic acid, see article upon it. For list of the bland oils, see Olive Oil.

W. P. Bolles.

ALOES (*Aloe*, U. S. Ph., Socotrine Aloes; *Aloe socotrina*, Br. Ph., which also recognizes Barbadoes aloes, *Aloe barbadensis; Aloë*, Ph. G., includes both socotrine and Cape aloes, the latter being mostly used in Germany; *Aloès*, Codex Med., is of two varieties, *L'Aloès du Cap* and *L'Aloès des Barbades*, a note being appended in which it is stated that the former is to be preferred and that Socotrine aloes is only accidentally in the market).

Aloes consists of the milky juice contained in the leaves of various species of aloe, evaporated to a thick or solid brown or black extract. The places of manufacture give the names to the different commercial sorts. It is one of the oldest of medicines, valued—according to tradition—long before the Christian era. Certainly it was known to the Greeks and Romans of the first century, and to the rest of Europe during the middle ages. It has always been extensively used and highly prized, as the fanciful names given to many of the older aloes compounds testify. The variety earliest known is, singularly too, the same which is still considered the best in England and America, and is nominally obtained from the same little, obscure, out-of-the-way island that Alexander is reported to have peopled with Greeks, in order to protect and improve its production. From Socotra the drug was formerly brought into Europe by the Red Sea and Alexandria. After the discovery of the route around the Cape of Good Hope, it followed the course of commerce in that direction; at present, Socotrine aloes is apt to go to India, and from there to England with the enormous mass of Indian products.

The less prized Barbadoes aloes has been produced in the West Indies for nearly two hundred and fifty years from cultivated plants. Cape aloes was first prepared a little more than a hundred years ago; the other varieties are mostly recent introductions. It is an abundant and rather cheap drug, of which there are many grades of value. Only a comparatively small portion of the entire amount is used in human medicine, as it is a favorite veterinary cathartic.

The flowers are borne on long spikes or racemes, which are sometimes forked, more usually, however, simple. They are tubular, nearly or quite regular, with a six-parted perianth, six stamens, and a three-celled, many-ovuled ovary. The fruit is a loculicidal capsule.

The genus comprises about eighty species, most of which are inhabitants of Southern or Eastern Africa. How many are concerned in the production of the drug is not known, but probably a number contribute to that obtained from the Cape.

Aloe vulgaris Lamarck is one of the best known species. It is found in Africa, India, the Mediterranean shores, and elsewhere, and is cultivated in the West Indies as the source of Barbadoes aloes. It is a low, thick plant, about half a metre in height (twenty inches), with a thick head of pale bluish-green, mottled leaves, about as long as the stem. The flowers are greenish-yellow, about three centimetres (one and one-fifth inch) long, in dense spikes. *Aloe socotrina* Lamarck, the reputed source of Socotrine aloes, grows in Socotra, and lately also in Southern Africa. It is a larger plant, from one to nearly two metres in height (three to five feet), with a stem a decimetre (four inches) in thickness, often forked. Leaves numerous, long and narrow, incurved. Spike about a metre long, scaly. Flowers purplish red, greenish at the tips.

The Cape aloes, as stated above, appears to be the yield of several species.

Aloe spicata Linn. f., one or two metres in height, and *Aloe ferox* Miller, one of the largest, sometimes twenty metres (over sixty feet) high, as well as several other species inhabiting Cape Colony, are regarded as affording Cape aloes.

There is still a considerable lack of definite knowledge concerning the sources of aloes that is remarkable, considering the length of time the drug has been used.

The preparation of aloes varies in details, but is nearly alike in principle, as far as known, wherever it is made, and consists in draining the cut leaves and evaporating the juice. Of Socotrine aloes the manufacture is not known, further than the merest outline. Herman states that the juice is evaporated in the sun. As the so-called Socotrine aloes comes from various places, and is by no means of uniform quality, it may not always be made in the same manner. The methods used at the Cape and in Barbadoes are so well and recently detailed from original sources in the *Pharmocographia*, that they are quoted here verbatim. "The cutting takes place in March and April, and is performed in the heat of the day. The leaves are cut off close to the plant, and placed *very quickly*, the cut end downward, in a V-shaped wooden trough, about four feet long and twelve to eighteen inches deep. This is set on a sharp incline, so that the juice which trickles from the leaves very rapidly flows down its sides, and finally escapes by a hole in its lower end into a vessel placed beneath. No pressure of any sort is applied to the leaves. It takes about a quarter of an hour to cut leaves enough to fill a trough. The troughs are so distributed as to be easily accessible to the cutters. Their number is generally five, and by the time the fifth is filled, the cutters return to the first, and throw out the leaves, which they regard as exhausted. The leaves are neither infused nor boiled, nor is any use afterward made of them, except for manure.

"When the vessels receiving the juice become filled, the latter is removed to a cask and reserved for evaporation. This may be done at once, or it may be delayed for weeks, or even months, the juice, it is said, not fermenting or spoiling. The evaporation is generally conducted in a copper vessel; at the bottom of this is a large ladle, into which the impurities sink, and are from time to time removed as the boiling goes on. As soon as the

inspissation has reached the proper point, which is determined solely by the experienced eye of the workman, the thickened juice is poured into large gourds, or into boxes, and allowed to harden."

At the Cape of Good Hope, "the operator scratches a shallow, dish-shaped hollow in the dry ground, spreads therein a goat-skin, and then proceeds to arrange around the margin a radial series of aloe leaves, the cut ends projecting inward. Upon this a second series is piled, and then a third, care being taken that the ends of each series overhang sufficiently to drop clear into the central hollow. When these preparations have been made, the operator either loafs about after wild honey, or, more likely, lies down to sleep. The skin being nearly filled, four skewers run in and out at the edge, square-fashion, give the means of lifting this primitive saucer from the ground, and emptying its contents into a cast-iron pot. The liquid is then boiled, an operation conducted with the utmost carelessness. Fresh juice is added to that which has nearly acquired the finished consistence; the fire is slackened or urged just as it happens, and the boiling is often interrupted for many hours, if neglect be more convenient than attention. In fact, the process is thoroughly barbarous, conducted without industry or reflection; it is mostly carried on by Bastaards and Hottentots, but not by Kaffirs." "The only aloe I have seen used," says Mr. MacOwan, "is the very large one with di- or tri-chotomous inflorescence—*A. ferox*, I believe."

Description.—Aloes varies considerably in appearance, independently of its botanical source, according to the mode of preparing it. It is sometimes inferior in consequence of dirt or adulteration, sometimes, probably, from careless boiling or other neglect. It, however, never loses its extractiform character, although it may vary very much in its consistency. Occasionally it is liquid. The Socotrine variety is often soft enough to be moulded like putty. Barbadoes and some samples of African aloes, when fresh, will generally flatten a little if large lumps are kept in a warm place and enclosed so as to prevent evaporation. The typical Cape aloes is, however, hard and very brittle. All varieties, if broken up and exposed to a dry atmosphere, become brittle, and may be ground to a fine powder, which, however, is apt to become cohesive. Occasionally, transparent pieces are seen, but only as curiosities. Lumps down to the size of a pea are almost always opaque, but most fine specimens of Cape and many of Socotrine aloes are translucent in thin sections or on the edge of fragments. Barbadoes aloes is usually very opaque; this opacity is sometimes due to impurities, sometimes to a feculent deposit of probably changed aloin in the manufacture, sometimes to crystals of aloin; when due to the latter cause, it is not an evidence of inferiority.

The color also varies. Fresh Socotrine aloes is usually yellow-brown, but upon exposure and drying grows darker and is then usually of a burnt sienna or burnt umber brown, sometimes reddish. Barbadoes aloes has a dark, cold, bistre-brown shade, becoming almost dull black. The best Cape varieties have a greenish-black color, and a bright glossy fracture. The powders are fawn-yellow, olive-yellow, and greenish-yellow respectively. The odor is bitter and nauseous, with a sort of resinous fragrance peculiar to each variety, and is relied upon by dealers in their estimate of the kind and quality; that of Socotrine is spoken of by authors as rather agreeable, *chacun à son gout.* It is certainly associated, in our minds, with the most prized aloes. Breathing upon the drug freshens and increases the odor.

The taste of all varieties is exceedingly nauseous and bitter.

Varieties.—These have been described in part in the general description above given; the remaining peculiarities may be summed up as follows: 1. *Socotrine aloes:* In original boxes or kegs, is almost always soft, and, in largish pieces, remains so for a considerable length of time; very soft, sticky specimens, requiring to be baled out on a spatula, are not uncommon; at length it dries and becomes quite brittle and crumbly. Its powder is yellow, buff, or reddish-yellow, *not greenish.* For color and odor see above. It is generally expected to be translucent in thin splinters, but varies. "Almost entirely soluble in alcohol, and in four times its weight of boiling water." 2. *Barbadoes aloes:* Imported in boxes or gourds, into which it has been poured while melted, and of whose shape the solid mass is a casting; generally pretty hard and tough; of a dark bistre-brown, fracture without lustre; powder dull olive-yellow. Odor rank and nauseous. 3. *Cape aloes:* Imported in casks or boxes; very brittle when dry; very dark greenish-black or pure black, with brilliant fracture. The pieces chafe each other like rosin, and the greenish-yellow powder can be seen at the corners and on the sides. Splinters generally translucent, odor strong, sourish. The solubility and general properties of the above two varieties are similar to those of Socotrine. The medical qualities are undoubtedly nearly the same. Besides these, *Curaçoa aloes, Natal aloes, Bonaire aloes* and others, have about the same properties. Hepatic aloes is a term without any very definite meaning, and is nearly obsolete.

Composition.—Aloes dissolves freely in alcohol, with the exception of its impurities, and even in spirit diluted to twenty per cent.; it is also soluble in three or four parts of boiling water, which, however, deposits about two-thirds upon cooling. Cold water extracts about forty-five or more per cent. of aloes, leaving behind about thirty per cent. of resin, five of albuminous matter and impurities. The most important constituents are the *aloins,* of which different varieties contain varying proportions. Flückiger gives from twenty to twenty-five per cent. as the yield of Barbadoes aloes, and from sixteen to twenty-five in Natal aloes. Socotrine aloes contains a large amount. From Cape aloes it has not been obtained crystallized, but an analogous amorphous powder is separated from it, and recognized as aloin by German pharmacists. Hager gives as the reason that the crystalline aloin is changed to amorphous by the boiling the juice undergoes in South Africa, but Barbadoes aloes is also boiled.

Aloin was discovered in 1850 by T. and H. Smith in Barbadoes aloes, later by Histed (or Pereira) in Socotrine, and by Flückiger in the Natal varieties, and it was also ascertained that the three constituents are not exactly the same in all respects; they have, accordingly, been distinguished as barbaloin, nataloin, and socaloin, respectively. Besides these crystalline aloins, corresponding amorphous substances are also found in the same drugs, and are probably, as suggested by Hager, produced, or at least increased, by prolonged heat. Their amount is very variable.

The formula of socaloin is given as $C_{16}H_{16}O_7$. Therapeutically the aloins do not appear to differ much. What we get as aloin in the market is, perhaps, not always the same substance. It is generally an amorphous, bright yellow powder.

Aloes contains a minute trace of essential oil.

Action and Use.—Aloes is a slow-acting purgative whose chief force appears to be expended upon the large intestine. In moderate doses it does not usually move the bowels before ten or twelve hours, when it produces often only one normal-appearing dejection; the contents of the rectum. In larger doses it does not act much sooner, nor proportionately more energetically, but the griping may be considerably increased. There is some reason to believe that it increases the blood-supply of the pelvic organs, at least of the rectum and uterus, and that it is of service in suppressed or delayed menstruation, both when produced by cold and by anæmia. In the latter case it is appropriately accompanied by iron. It has a popular reputation for producing or aggravating hæmorrhoids, which is the legacy from the medical teaching of a previous generation. In suitable doses or cases it certainly does not do so. Whether it might produce this effect when used as a drastic frequently and without sufficient cause, the writer does not know. It is undoubtedly now generally used in smaller doses than formerly. As a *purgative,* either to produce a derivative action, or to clear the whole intestinal tract or remove the cause

of an attack of indigestion, aloes alone, when other means can be obtained, is not generally the most suitable drug for the purpose, on account of its slowness of action. For the same reason it is not so profitable to combine it with the other quick-acting cathartics, as, if given together, they do not act synchronously. But a dose of aloes may often be advantageously supplemented by some other purgative, given five or six hours later. In the large class of cases of chronic constipation, when through neglect or irregular habits, or atony or diminished irritability of the large intestine, the rectum is continually filled or even distended with fæces, for certainty and quietness of action there are few drugs which can compare with it. It has also the unusual property of not producing tolerance, so that it can be given for a long time without losing anything of its valuable effect. The external use of aloes is nearly obsolete.

ADMINISTRATION.—One gramme (gr. xvss.) of good aloes will usually act as a free, sometimes drastic, and griping purgative, and may be considered to be a full average dose for this purpose. Two or three decigrammes (gr. iij. to gr. v.) will usually move the bowels once quietly; and one or two decigrammes (gr. jss. to gr. iij.) daily will, in the same way, relieve moderate constipation. These doses are only given as approximations, and should be always adjusted to the patient's responsiveness, the smallest dose being chosen which will answer the purpose. It is better to use a cleaner product than ordinary aloes, however, and two such are officinal, viz., Aloe Purificata and Extractum Aloes Aquosum. *Aloe Purificata*, U.S.Ph., is prepared by melting, thinning with a little alcohol, straining, and evaporating to dryness. It contains all the constituents, excepting mechanical impurities, and perhaps some precipitated gum, and is simply clean aloes. This is used in making all the other preparations. Its dose is about the same; theoretically, it should be a little less. *Extractum Aloes Aquosum*, U. S. Ph., is prepared by dissolving crude aloes in boiling water and, after the solution is cold, straining it and evaporating to dryness. This separates impurities and resin, and yields something more than fifty per cent. of the amount of aloes used; but the result varies. Dose about one-half that of crude aloes. Fortunately the doses of aloes are small enough to be given in the form of pills, which is now the general method. Several are officinal, almost classical: *Pilulæ Aloes*, U.S. Ph.: Aloes and soap, equal parts, two grains of each in every pill. *Pilulæ Aloes et Asafœtidæ*, U. S. Ph.: One grain of each, and one grain of soap in each pill. *Pilulæ Aloes et Mastiches* ("Lady Webster's Pills" essentially), U. S. Ph.: Aloes, two grains; mastiche, one-half grain; red rose, one-half grain. And finally, *Pilulæ Aloes et Myrrhæ*, U. S. Ph., with two grains of aloes, one grain of myrrh, and one-half grain of aromatic powder (cinnamon, ginger, etc.). All but the first are essentially duplicates—aloes and corrigent. *Pilulæ Aloes et Ferri*, U. S. Ph., containing aloes, dried sulphate of iron, and aromatic powder, of each one grain, contain also an efficient dose of iron, and are useful in constipation with anæmia, amenorrhœa, and in similar conditions. Extemporaneous pills of aloes can easily be made, associating atropine, extract of belladonna, extract of nux vomica, or other suitable adjuvants. Such pills are considerably used.

The liquid preparations are venerable but less useful, and will scarcely be tolerated on account of their taste by any one able to swallow a pill. They are *Vinum Aloes*, U.S. Ph., strength, not quite one-sixteenth, corrected with ginger and cardamom; *Tinctura Aloes*, U.S. Ph., strength, one-tenth, flavored with liquorice; *Tinctura Aloes et Myrrhæ*, U. S. Ph., strength, one-tenth of each ("Elixir Proprietatis" approximately). *Aloin*, not officinal, is considerably used. It is hardly yet a uniform substance. The Germans require an amorphous article prepared from Cape aloes, and do not appear to regard it very highly. That which is used in England and in the United States resembles exactly some impure barbaloin in the writer's possession, and is perhaps the same. Authors differ in their estimate of it; his acquaintance has been favorable; pills containing one or two milligrammes (grain one-sixth to grain one-third) with a little strychnine or atropine have appeared fully as useful in his hands as the larger aloes pills, and far more elegant.

There are innumerable non-officinal preparations of aloes, many of them having a historic interest and christened with quaint and fanciful names. It is also a leading ingredient of numerous popular *arcana*. For a long list of these, see Hager's "Pharmaceutische Praxis" and other works on pharmacy.

ALLIED PLANTS.—For a notice of the order *Liliaciæ*, see Squill. The *Yuccas* were referred to above, as well as the *Agaves*, which appear to take their place on the American continent. Besides these, there is not much suggestive in their relations. *Xanthorrhœa*, which by some botanists is placed near *Aloe*, resembles it in habit and in having a resinous juice, of, however, an entirely different character (see Acaroides).

ALLIED MEDICINES.—The vegetable cathartics; for a list of them see Senna. *W. P. Bolles.*

ALOPECIA. By the term alopecia is understood a general or local loss of hair to an abnormal extent. The most convenient method of considering the several varieties of alopecia is that adopted by Michelson (Ziemssen's "Handbuch der Speciellen Path. u. Ther.." Bd. 14, Hälfte 2, S. 106), who divides the subject as follows: (1) Alopecia congenita; (2) alopecia symptomatica; (3) alopecia senilis and pre-senilis; (4) alopecia pityrodes; (5) alopecia simplex; (6) alopecia areata; (7) alopecia neurotica.

Congenital alopecia is rather an anomaly than a disease. Although rare, cases have been met with where infants born without hair have developed first a growth of lanugo or fine wool-like short hairs; and later, usually by the third year, a more or less considerable growth of hair. More rarely, however, congenital baldness, which may involve all parts of the body as well as the head, is a permanent condition, and the individual remains almost or entirely bald throughout life. As in the case of hirsuties, or abnormal growth of hair, anomalies in the growth and distribution of the teeth are apt to be observed in connection with congenital alopecia. I have had under observation a gentleman who was born nearly or quite bald, and, until the age of three years, showed only lanugo upon the scalp. The hair then began to grow quite luxuriantly, and he continued to enjoy a full suit of hair until after his twentieth year. The hair then began to fall out, as in ordinary premature alopecia, and continued to do so until a patch of almost complete baldness extended from the forehead nearly to the occipital regions on either side. The hair which was of a very light brown shade grew to a moderate degree on the eyebrows and face generally. Over the body, the hair growth is at the present time normal. This gentleman displays an excellent set of teeth as regards condition. The first teeth, however, are somewhat misshapen; some only partly project beyond the gum, and one of the upper incisors is entirely missing. The finger-nails are normal.

Cases are on record of persons who have reached adult age without having either teeth or hair.

Localized congenital alopecia has been observed in a number of cases. There is little or no prospect, so far as experience has shown, that the hair will ever be restored in these cases. In fact, the tendency is to the development of new centres of alopecia.

The causes which lead to congenital baldness are not known; but it is evidently an anomaly of development finding its origin in intra-uterine life.

Microscopic examinations of portions of skin taken from well-developed patches of baldness have shown well-developed sebaceous follicles, with a free opening directly upon the surface. Partly developed embryonal hairs have also been found. Extreme cases have shown the cutis of the hair region supplanted by a stringy areolar tissue containing fat-cells and collections of granules. Among these, altered follicles, with here and there papillæ, have been observed. The epidermis was atrophic.

Alopecia symptomatica is that shedding of the hair which is due to local causes, and confined to limited areas. The skin and hair being but parts of one system, it is easily understood that when one suffers the other must be affected. Thus, an acne pustule may involve and destroy the life of the hair about which it forms, or an attack of erysipelas may give rise to a general shedding of the hair. This fall of hair, however, is in each case rigidly limited to the area of the local disease which is its cause.

Symptomatic alopecia may occur as the result of scaly diseases like psoriasis, but it is more apt to be found in connection with inflammatory affections of the skin, as eczema, acne, erysipelas, variola, the vegetable parasitic diseases, and also in connection with syphilis and other new growths. Compression of the skin, as by tumors, may also give rise to symptomatic alopecia.

The pathology of this form of alopecia is closely connected with that of the causative affection in each case, and the prognosis likewise depends upon the character of the local affection. When this is ulcerative and ends in scarring, as in ulcerative syphilis, some forms of lupus, tinea favosa, etc., no restoration of hair can be looked for. When, however, the local disorder has been a simple inflammation, as psoriasis, erysipelas, etc., complete or almost complete restitution of the hair may be expected.

Alopecia senilis and pre-senilis is that form of loss of hair which is usually connected with the advance of age. It is confined almost invariably to the hair of the head (scalp); the body hair may be thin or thick, may decrease or increase, but with the advance of age the hair of the scalp almost always becomes thinner as the skin generally takes on the retrogressive changes of old age.

The baldness of old age commonly precedes the graying of the hair, and occurs more frequently in men than in women. It usually begins on the vertex and spreads gradually forward and laterally. The hair does not fall out entirely and at once, but the normal hair is succeeded by fine woolly hairs, "lanugo."

Premature baldness, alopecia pre-senilis, is like the baldness of old age, excepting that the hair does not fall so rapidly, and that the lanugo only succeeds the long hair on the vertex, the other parts, according to Pincus, becoming completely bald without any intermediate stage.

The skin, in premature and senile baldness, is thinned, somewhat tense, but movable over the parts beneath. In well-nourished persons the scalp has an oily look under the skin.

The pathological appearances in this form of alopecia are, according to the German authorities (Michelson), those of retrogressive metamorphosis in the skin. A fibrous endarteritis narrows the lumen of the cutaneous arteries and the rich capillary network filling the connective tissues under the skin, and particularly surrounding the hair-sacs, gradually disappears. The sebaceous and sweat-glands are slightly, or not at all, involved in this degenerative process. In premature alopecia of an advanced stage the appearances are the same as those presented in alopecia pityrodes, only the thinning of the middle layer of the skin is still more marked.

No treatment of this form of alopecia is of any avail.

Alopecia pityrodes is one of the commonest forms of alopecia, and, thanks to the laborious studies of Pincus, one of the best understood of all forms of disease connected with the loss of hair. In order to set forth more fully the characteristics of this affection, a few words may be said with regard to the normal growth and shedding of the hair.

Each hair has a certain rate of growth and a certain typical length, varying in different individuals and in different parts of the body, but which in each case is normally constant. The duration of life of the individual hair varies from two to six years; at the end of its period of life it falls out and is replaced by a new hair.

Any influence which shortens the life of the hair tends to baldness in two ways: by the preponderance of short-lived hairs, and by the slow diminution in the length of the full-grown hairs, which fall out before they have attained their typical length.

Such influences are at work in alopecia pityrodes. The patient, who is always an adult, or who at least has passed the age of puberty, begins to notice slight thinning of the hair. This goes on through successive years until baldness begins to show itself, usually at first at the vertex and above the forehead. At the same time, if the hairs which fall out day by day are carefully examined, a noticeable number of "pointed hairs" will, in the case of men, be found among those cut off at the ends. These pointed hairs are the ones which have lived out their life and fallen out before attaining a sufficient length to be cut by the scissors. Their number in proportion to the entire number of hairs shed will give a rough guide to the extent to which the disease has gone. For with each reproduction in these cases the hair lives a briefer life and dies at a shorter length, so that in a case which is progressing, a larger proportion of short hairs are continually appearing in the combings. At the same time a certain number of hairs become diminished in volume, and assume the character of lanugo, or fine woolly hairs.

The process, if unarrested, goes on until the healthy hair growing on the vertex of the scalp has been succeeded by lanugo, and, the lanugo disappearing, the scalp is left bald, shining, and smooth as ivory. In this form of alopecia, the baldness having affected a certain area goes no further, until old age brings with it senile alopecia, which pushes its ravages still farther into the scanty crop of hair remaining.

One of the earliest symptoms of alopecia pityrodes to attract attention is the scaliness of the scalp, an abundant formation of branny epithelial scales, the increase of which usually goes *pari passu* with the loss of hair, but is occasionally only slight through the whole course of the disease. This furfuraceous desquamation is called "pityriasis," or popularly "dandriff."

The only subjective symptom attending this form of alopecia is a certain prickling or itching sensation in the scalp, with an occasional feeling of heat.

Alopecia pityrodes is more rarely encountered among women than among men. It runs essentially the same course, only ceasing its destructive progress, however, in the former before entire baldness supervenes.

Hereditary predisposition is perhaps the most important factor in the etiology of alopecia pityrodes. Various debilitating diseases, as scrofula, syphilis, fevers, the puerperal state, nervous and mental disturbances, may directly or indirectly induce the affection, while among women anæmia and chlorosis are often the cause of its occurrence. It was formerly believed that atrophy or some other condition of the nerve-supply was the cause of alopecia pityrodes, but this view lacks confirmatory pathological basis. Some Germans have fancied it to be due to a parasitic affection, but this theory also lacks confirmation.

Examination of sections of the skin from the bald scalp in alopecia pityrodes shows that the middle layer of the true skin between the epidermis and the subcutaneous connective tissue is invariably thinned, while the panniculus adiposus is thickened with usually so much increase in fibrous meshwork as to account for the tense adherence of the scalp observed clinically. There is no change whatever in the vascular supply, nor in the condition of the blood-vessels. The hairs themselves do not differ microscopically from such as die and fall from healthy scalps, excepting that, as in other forms of atrophy of the hair (see Hair, Diseases of), increased brittleness is observed in the early stage.

Microscopic examination of the accompanying pityriasic epithelial scales shows them to be composed of epithelial cells from the horny layer of the epidermis, many of them fattily degenerated, but, as I showed some years ago, not to be confounded with the crusts of seborrhœa capitis. (See Pityriasis and Seborrhœa.)

The *diagnosis* of alopecia pityrodes is usually not difficult. The accompanying pityriasis is the most characteristic symptom, although this may be so slight at times as not to attract attention.

The *treatment* of alopecia pityrodes is essentially that

of pityriasis capitis (q. v.). The scales should be removed by vigorous shampooing with a soap solution and, subsequently, some oil or ointment should be firmly and thoroughly rubbed into the scalp over all the affected portion. Cold-water douches, followed by brisk brushing and rubbing and the application of one of the remedies mentioned below, under alopecia areata, may also be useful. Internal remedies rarely prove of value in this form of alopecia, although any obvious weakness of constitution or disease should be combated, because the alopecia of debility, transient in itself, may pass on to alopecia pityrodes.

The *prognosis* of alopecia pityrodes is unfavorable, particularly where there is a strong hereditary tendency to early baldness. Much can be done, however, if treatment is instituted at an early stage of the disease. The sooner after puberty this form of alopecia appears, the more rapid is its course. The duration and amount of pityriasis present is to some extent a measure of the past duration and severity of the disease. The increase or decrease in the proportion of pointed hairs found in the combings is also a gauge. Pincus suggests that the combings be collected daily for four successive days, and that each day the comparative number of pointed hairs be counted. If the proportion of pointed hairs is to the entire combing as one to eight, the average length of the cut hair being five inches, or as one to ten, the average length being two to three inches, then the amount of hair shed is abnormal. It is not the number of hairs shed which should arouse apprehension, but the large proportion of pointed or short-lived hairs. In the case of women, where all the hairs are pointed hairs, a decrease in length from the typical standard is significant in the prognosis in proportion to its extent.

Under the name of *alopecia pityrodes universalis* Michelson describes a form of alopecia which in many respects resembles alopecia areata of the malignant variety. The affection begins suddenly and severely, by a rapid and increasing thinning of the hair in various parts of the scalp, preceded and accompanied by an increased desquamation of fatty epidermis. The affection differs from alopecia areata in that the patches are at no point completely bald, but are covered with fine colorless lanugo hairs, or at least show rudimentary hairs in the follicles, and also that the transition from the affected area to the surrounding healthy hair is not abrupt, but gradual. The parts usually attacked by alopecia pityrodes localis are those first attacked by the universal variety. Unlike alopecia areata, the skin in alopecia pityrodes universalis is not thinned.

Debility from various causes seems to be the chief exciting etiological factor. Salt baths, tonic medicines, and nourishing food are called for in the way of treatment, with shampooing of the scalp and stimulant applications. The prognosis is favorable.

Alopecia simplex is the name given by Pincus to those exceptional cases of falling of the hair which in their general course resemble alopecia pityrodes, but in which one essential feature of that affection is wanting, namely, the increased desquamation of the epidermis. The management of such cases does not differ essentially from that of alopecia pityrodes, excepting that, instead of the shampooing with soap washes, etc., to remove the epidermic scales, stimulating applications alone are called for.

Alopecia areata is an affection which has been known from the earliest ages of medicine, its striking characteristics having attracted the attention of authors who have passed over most other skin affections in silence. It has been described under the various names of area Celsi, alopecia circumscripta, alopecia accidentalis, porrigo or tinea decalvans, and *pelade* or *teigne pelade*. It is characterized by the usually sudden appearance of one or more roundish, somewhat sharply defined, circumscribed bald patches which may spread slowly at the periphery and finally may run together, forming larger irregular patches, or leading to entire loss of all the hair on the head and body. The skin itself remains nearly or quite unchanged.

In the milder form of the disease, as usually encountered, a single patch, or a few patches of small size, situated on the scalp or in the beard constitute the whole disease. This form is called by Michelson the "benign" form. The severe cases eventuate in a total loss of hair from every part of the body, and are called by Michelson "malignant."

Alopecia areata is a comparatively rare disease in this country, although I imagine less rare than in Europe. The statistics of the American Dermatological Association show 350 cases in a total of over 58,000 cases of skin diseases, a proportion of about one-half of one per cent. It usually occurs among comparatively young persons, but may occasionally attack persons of mature years. It occurs in both sexes.

The disease is sometimes ushered in by subjective symptoms, as headache, itching, tingling, or warmth of the part to be affected, but more commonly the hair falls without warning; a whole bunch may come out at once while dressing the hair, or during the night. The patch affected may be perfectly bald, or a few straggling hairs, quite healthy in appearance, may be left. About the edge of the diseased patch short broken-off hairs are sometimes found in small numbers. In the earlier stages of the disease the openings of the hair-follicles are quite perceptible, but if the process has gone on for some time these ducts collapse, and in advanced cases are hardly perceptible. The skin, in severe cases, is abnormally pale, responding to stimulation, however, but soon recovering its pale tint. The affected skin is at first slightly raised above the surrounding surface, but later sinks below it and becomes abnormally movable over the cranium, owing to the partial disappearance of the panniculus adiposus. The sensibility of the affected patches is in no way altered.

Fig. 79.—Alopecia Areata. (After Michelson.)

In the ordinary milder form of the disease entire baldness of the affected patches only lasts a short time. Some fine lanugo hairs make their appearance which may give place to a stronger growth, or may fall out and gradually be replaced by another crop of downy hairs. This growth and fall of ill-developed hair may continue for months, or years almost, before the patch is finally covered with healthy hair. While one patch is becoming covered, the hair may begin to fall out at another point, and a case observed in the full height of the disease will often be found to show bald patches, patches covered with lanugo, others thinning rapidly, and still others becoming regenerated.

Under the name of malignant alopecia are included those, fortunately rare, cases where a more or less rapid fall of hair from all parts of the body takes place, resulting in absolute baldness. Michelson says that these cases recover by very slow degrees. I have seen four cases of general alopecia, three of which were under my observation for several years without visible improvement, while the fourth occurred in an elderly man who had been quite hairless for a number of years.

The *etiology* of alopecia areata has never yet been satisfactorily settled. Two theories have for some years past divided dermatologists, the neurotic and the parasitic. Against the latter view we have the fact that the clinical appearances presented by the disease are in no way like those of other vegetable parasitic skin diseases, and also that each discoverer of fungus in the disease depicts a different variety from all previous observers. Finally, also, antiparasitic remedies have no effect toward

the cure of the disease. Proof of the neurotic origin of alopecia areata has been sought in the (supposed) change of sensibility in the skin, in the occurrence of nervous symptoms at the outbreak of the disease, and in the resemblance of the patches of alopecia areata to those bald patches which occur as the direct result of nerve injuries (see alopecia neurotica). In addition, the facts that the disease is occasionally known to occur in near relatives (heredity), and finally that loss of hair has been produced by section of certain nerves more or less connected with the locality, have been brought forward in favor of the neurotic origin of the disease. None of these theories is satisfactory, and although the pallor of the skin in the diseased areas leads to the view that a vaso-motor disturbance may be connected with its occurrence, yet even this leads us only one step farther back, and it must be admitted that for the present the true etiology of this curious affection remains unknown.

Microscopic examination of sections of the skin in alopecia areata have thus far yielded little result. The skin is thinned, but not abnormal beyond showing premature cornification of the hair. The existence of a vegetable parasitic growth about the roots of the hair has frequently been asserted, but no convincing observations to this effect have been brought forward.

The *diagnosis* of alopecia areata as usually found upon the scalp and head is not difficult. The one disease with which it is liable to be confounded is tinea tonsurans, or tinea barbæ. In the latter, however, the patch, instead of being smooth and white, is ashen gray, with a nutmeg-grater surface covered with broken-off stumps of diseased hairs. Microscopic examination of scales or broken stumps from the diseased patches will decide the diagnosis in doubtful cases. It is possible that a patch of tinea tonsurans, when the disease has been cured and nothing more than baldness exists just before the new hairs are reproduced, might be taken for alopecia areata. Here, however, the history of the case will settle the question.

FIG. 80.—Universal Alopecia. (After Michelson.)

The *treatment* of alopecia areata consists essentially in tonics and supporting diet, with the local employment of rubefacients. Iron, quinine, arsenic, and cod-liver oil may be used as the case demands. Blistering the patches repeatedly with cantharidal collodion and cantharides in combination, or even as the pure tincture, may be employed. The following combination is a good one: ℞. Tinct. cantharidis, f ʒ iij. (10.10 gm.); tinct. nucis vom., f ʒ ij. (6.75 gm.); aceti destillat. f ʒ vj. (20.25 gm.); glycerinæ, f ʒ j. (5 gm.); aquæ, ad f ℥ iij. (90.00 gm.). M. The following formula of Wilson is much used—its virtues reside in the liquor ammoniæ: ℞. Olei amygdalæ dulcis, f ℥ j. (27.00 gm.); liq. ammoniæ fort., f ℥ j. (30.00 gm.); sp. rosmarini, f ℥ v. (135.00 gm.); ol. limonis, f ʒ j. (3.40 gm.). M. Electricity has also been recommended by means of the faradic current, with one pole upon the back of the neck and the other armed with a fine metallic brush to the affected part.

The *prognosis* of alopecia areata is on the whole favorable, although, even in the mildest form, months or even a year or more may elapse before the hair is fully restored. Relapses also are not uncommon, and beyond a general prediction of final recovery, it is unsafe to hazard a prognosis as to time in any case. Cases of general alopecia, the "malignant" alopecia of Michelson, may last for years, and yet he says the patient may finally recover the full growth of hair.

Under the name of *alopecia neurotica*, Michelson includes such cases as occur in connection with diseases on which they may be supposed to depend, and where the loss of hair is confined to the area supplied by certain nerves. How the falling of the hair is connected with nerve influence we cannot on the solid basis of anatomical or physiological research say: clinical facts alone support the view taken. Cases have been reported where entire loss of hair over the whole body has resulted from brain injury. Similarly injury to one lateral half of the brain has been followed by unilateral alopecia. Injury to nerve-trunks is likewise at times followed by alopecia of the region supplied. Alopecia may accompany unilateral atrophy of the face and similar trophoneurotic affections, also neuralgia.

Arthur Van Harlingen.

ALPENA WELL. *Location and Post-office,* Alpena, Alpena County, Mich.

ACCESS.—From Bay City, Mich., by steamer to Alpena, about one hundred and ten miles north, on the shore of Thunder Bay.

ANALYSIS (Professor S. P. Duffield).—One pint contains:

	Grains.
Carbonate of potassa	Trace.
Carbonate of soda	1.364
Carbonate of magnesia	4.661
Carbonate of iron	0.170
Carbonate of lime	4.787
Chloride of sodium	8.532
Sulphate of lime	3.757
Alumina and silica	0.386
	23.657

Carbonic acid gas, 1.05 cubic inch; sulphuretted hydrogen, 4.42 cubic inches; nitrogen, 0.03 cubic inch.

This artesian well is 900 feet deep. The water has a temperature of 52° F.

THERAPEUTIC PROPERTIES.—This water is celebrated for its unusual proportion of sulphuretted hydrogen, being equal, in this respect, to any in Europe or America. The claim of magnetic properties is not sustained. The locality is cool in summer, and healthful at all times.

G. B. F.

ALPS. The extensive and lofty group of mountains occupying the central region of Europe, in Switzerland, Savoy, Southern Bavaria, and Western Austria, and separating Italy from the colder countries which lie to the north of it, presents to the invalid a great variety of places of resort, some chiefly serviceable during the summer months, some during the winter season, and some of them available as sanitaria at all times of the year. For a discussion of the peculiar properties and advantages of the more elevated of these health stations see article on Mountain Climate; for description of the special features of individual stations of the more truly Alpine class see Davos, Wiesen, St. Moritz, etc.; for accounts of individual resorts lying on a lower level than those just mentioned, see Vevey, Meran, Montreux, etc.

H. R.

ALTERATIVES. (Syn.: Catalytics, eutrophics.) The class of remedies thus designated are agents which, promoting nutrition, so *alter* the course of morbid processes as to lead to the elimination of disease and a return of the organism to a normal, healthy condition. This change occurs without any clear evidence of drug action upon the various organs, and without any notable increase in the excretions from the body. The mode of action of alteratives is at present but imperfectly understood, and we have, for the time being, to content ourselves with the knowledge, gained empirically, that certain diseases or dyscrasiæ are alleviated or cured by the exhibition of certain remedies. We may in time learn the why and the wherefore of certain alterations which now are evidenced only by results, but that time is not yet. But, although we are obliged to confess ignorance as to the manner in which these remedies influence disease, we must nevertheless acknowledge the fact that they do so, and, as Wood so justly insists, it is not

the part of wisdom to reject the teachings of empiricism simply because they cannot be satisfactorily explained.

The remedies which are most frequently employed for their alterative effects are: Arsenic, iodine, mercury, phosphorus and the hypophosphites, sulphur, cod-liver oil, colchicum, guaiac, sarsaparilla, and water.

USES.—Arsenic is employed in a variety of skin diseases affecting the superficial layers—rete and epidermis. It should never be given in the acute inflammatory stage, and is of little value in those diseases which involve the deeper layers of the integument. It seems to be especially indicated in squamous affections associated with the rheumatic diathesis. It is also of frequent use in malarial cachexia. Iodine and its preparations are used in scrofula and syphilis; the tincture is employed both externally and internally in scrofula, and is especially valuable in the treatment of indolent glandular enlargements, but is of less service when suppuration is present. In the suppurative stage of scrofulous gland disease, cod-liver oil is to be preferred. The iodides are employed in tertiary syphilis and in chronic metallic poisoning, more particularly in lead-poisoning and the mercurial cachexia. Mercury is given in secondary syphilis and to promote the absorption of plastic exudations of the serous membranes. In purgative dose, mercury relieves the condition known as biliousness. Phosphorus and the hypophosphites are exhibited with benefit in scrofulous bone affections and in rachitis. Sulphur finds employment in the prevention of abscesses, boils, and other suppurative affections. It is usually given for this purpose in the form of the sulphide of calcium. Cod-liver oil is used in all conditions of malnutrition and anæmia, in rachitis, scrofula, tuberculosis, and whenever there is a tendency to cell proliferation. Colchicum is the remedy for gout and the gouty diathesis; it is usually given in combination with a salt of potassa. Guaiac is exhibited with apparent benefit in subacute and chronic rheumatism and in syphilis. The al terative action of sarsaparilla has been disputed; it has a great popular reputation, however, and is the principal ingredient of many of the "blood purifiers," and other nostrums, which are consumed in such quantities all over the civilized world. It is certainly harmless in its effects, and is a pleasant excipient for the exhibition of other more reliable alterative remedies. Finally, water is an excellent solvent of effete matters within the system; when given in large quantity it enhances very materially the beneficial effects of the iodides and other alteratives, and, indeed, the former should always be taken with copious draughts of water. *Thomas L. Stedman.*

ALUM, POISONING BY.—Cases of poisoning by this drug are rare. The symptoms appear very soon after the poison has been swallowed. There is severe pain in the œsophagus and stomach, followed by vomiting, often of blood; sanguineous discharges from the bowels, and all the symptoms of a violent gastro-enteritis. The pulse is small and frequent; there is muscular tremor with great weakness; thirst is sometimes excessive, and swallowing is difficult and painful; the body temperature is lowered. Death may occur in syncope. Alkalies and their carbonates and calcined magnesia are the antidotes for alum. After the immediate danger has passed away, the gastro-enteric inflammation remains to be treated on general principles. Chronic alum poisoning is manifested by gastric disturbance and constipation. It is to be treated by first removing the cause, and then combating the effects by means of laxatives and stomachics.

T. L. S.

ALUMINIUM. 1. GENERAL MEDICINAL PROPERTIES OF THE COMPOUNDS OF ALUMINIUM.—As compared with the majority of the heavy metals, aluminium exerts but an insignificant constitutional action—one useless in medicine, and not certainly recognizable even in poisoning by aluminium compounds. All the evidence there is of constitutional action of this metal is that, in toxic doses of alum, there have been observed along with the symptoms of local irritation, tremors, spasms, fainting fits, and, in one case, death, with disproportionately slight local lesions. Locally, aluminium compounds are astringent; the freely soluble, such as alum, highly so, but yet with less conjoint irritation than is usual with astringent metallic salts. The main therapeutic use of aluminic preparations is for a local astringent effect, for which purpose these compounds combine potency with freedom from bad taste, undue irritation, or power to stain.

2. THE MEDICINALLY-USED COMPOUNDS OF ALUMINIUM.—These are the hydroxide, sulphate, and potassio-sulphate (potassa alum).

Aluminic hydroxide, $Al_2(OH)_6$. Aluminic hydroxide, or hydrated alumina, as it is commonly called, is officinal in the U. S. Pharmacopœia as *Aluminii Hydras*, Hydrate of Aluminium, Hydrated Alumina. It is prepared by precipitation, a boiling-hot aqueous solution of alum being poured into a similarly hot solution of sodic carbonate. The precipitate of the hydroxide is then washed with hot distilled water, drained, dried, and pulverized. The product is "a white, light, amorphous powder, permanent in dry air, odorless and tasteless, and insoluble in water or alcohol. Soluble, without residue, in hydrochloric and sulphuric acids, and also in solution of potassa or soda. When heated to redness it loses 34.6 per cent. of its weight (water of hydration)" (U. S. Ph.). This preparation, from its insolubility, can exert active properties only through chemical conversion. Locally applied, it operates as an absorbent powder, developing, possibly, a faint astringency. Its employment is almost exclusively German, and consists in its application to the skin in inflammatory affections.

Aluminic sulphate, $Al_2(SO_4)_3.18H_2O$. The salt is officinal in the U. S. Pharmacopœia as *Aluminii Sulphas*, Sulphate of Aluminium. It occurs as "a white, crystalline powder, permanent in the air, odorless, having a sweetish and, afterward, astringent taste, and an acid reaction; soluble, without leaving more than a trifling residue, in 1.2 parts of water at 15° C. (59° F.), and very soluble in boiling water; almost insoluble in alcohol. When heated, the salt melts in its water of crystallization, and at or near 200° C. (392° F.), it loses the whole of it, amounting to 48.6 per cent. of its weight" (U. S. Ph.). Aluminic sulphate is powerfully astringent, and also antiseptic. Its use is local only, as a conjoint astringent and detergent, or, in saturated solution, as even a mild caustic in simple hyperplasiæ.

Potassio-aluminic sulphate, $K_2Al_2(SO_4)_4.24H_2O$. This double salt is officinal in the U. S. Pharmacopœia as *Alumen*, Alum. In the revision of the Pharmacopœia of 1870 the title *alum* was transferred to the ammonio-sulphate, a salt indistinguishable from the present except by chemical tests (rubbing with potassa or lime and a little water, when an ammoniacal odor will be evolved). This was because the ammonia-alum, from its cheapness, had come to be largely used instead of the older potassic compound. The Pharmacopœia of 1880 has, however, returned to the potassa-alum, and does not even recognize the ammonic salt as an alternate preparation. Alum is in "large, colorless, octahedral crystals, sometimes modified by cubes, acquiring a whitish coating on exposure to air, odorless, having a sweetish, astringent taste, and an acid reaction. Soluble in 10.5 parts of water at 15° C. (59° F.), and in 0.3 part of boiling water; insoluble in alcohol. When gradually heated the salt loses water; at 92° C. (197.6° F.) it melts, and if the heat be gradually increased to 200° C. (392° F.), it loses 45.57 per cent. of its weight (water of crystallization), leaving a bulky, white residue" (U. S. Ph.). Alum is decomposed by the alkalies and their carbonates, lime, magnesia and its carbonate, potassic tartrate, and lead acetate. The salt is highly astringent, and, internally, in dose of from 4 to 8 gm. or more (one or two drachms), is promptly and efficiently emetic, with little nausea or depression. In large concentrated dosage it is an irritant poison, but death is rare. Alum is principally employed locally as an astringent. For limited application to an accessible part a smooth crystal may be swept over the surface, but more commonly aqueous solutions are used, ranging in strength from one-half of one per cent. to three or four per cent., according to the sensitiveness of the part. A

domestic but serviceable form of application, is *alum curd*, made by boiling alum in milk, one part to sixty, until coagulation ensues, then straining and applying the curds like a poultice between layers of fine linen. Or the curd may be obtained by mixing 2 gm. (thirty grains) of powdered alum with the white of an egg. Alum may be almost universally used for astringent purposes, except that as a gargle it is objectionable because of an injurious action upon the teeth, and as a collyrium because of its attacking and softening the tissue of the cornea wherever the protective influence of the epithelium may be wanting, as in case of abrasion or ulcer.[1] Internally alum may be used as an emetic in the doses stated above, and has been held for a century—off and on—to be of peculiar avail in lead colic, abating all the symptoms, even to breaking the tendency to constipation. For internal astringent medication alum is, nowadays, comparatively seldom used, other astringents being preferred. The dose of alum is from 0.30 to 1.00 gm. (five to fifteen grains) in powder, with sugar and an aromatic, or in mixture with honey or molasses. Or *alum-whey* may be given —simply the whey left after straining out the curds in the preparation of the latter from alum and milk as described above. Such whey may be given by the wineglassful. These various dosings may be repeated three or four times a day, or, in lead colic, given even hourly.

As has been already said in the quoted description of alum, the salt parts with water of crystallization when heated to about 200° C. Such heating of effloresced alum, continued till the alum has been reduced to a standard weight, is ordered by the U. S. Pharmacopœia, and the product, pulverized, is entitled *Alumen Exsiccatum*, Dried Alum, more commonly called *burnt alum*. Dried alum is "a white, granular powder, attracting moisture when exposed to the air, odorless, having a sweetish, astringent taste, very slowly but completely soluble in twenty parts of water at 15° C. (59° F.), and quickly soluble in 0.7 part of boiling water. It answers to the same reactions as alum" (U. S. Ph.). Dried alum dissolves more slowly in water than the crystalline, but is, yet, physiologically much more active, for it is powerfully astringent even to causticity, and its use is, applied dry, to cauterize exuberant granulations or unhealthy ulcers, or to repress hæmorrhage as from a leech-bite or tooth-socket.

Edward Curtis.

[1] John Tweedy: The Practitioner, November, 1883, p. 331.

AMBER, Succinum. (Preparation: *Oleum Succini*, U. S. Ph.).

A fossil resin produced by *Pityoxylon succiniferum* Kr. and other tertiary, and long ago extinct *Coniferæ*. The range of these trees must have been a considerable one, as amber has been found in many widely separated places—Siberia, Alaska, Greenland, Maryland, in the United States, and in nearly all quarters of Europe. But the tract now covered by the Baltic Sea must have produced these trees in the greatest abundance, for from its southern borders nearly all the amber of commerce is, and for many centuries has been, obtained. The west coast of Denmark, and nearly the whole north coast of Prussia is included in this amberiferous region. It is continually found cast upon the shores by the waves, especially after heavy storms, either loose or entangled in the "roots" of *fuci* and other marine algæ; it is also fished up from the bottom; and finally, large quantities are dug out of a stratum of glauconitic sand, "blue earth," underlying layers of peat and marl, and extending often far beneath the bed of the sea. It is assorted into numerous grades, according to its purity and size, the finest pieces are cut and polished for articles of ornament, the small and unsightly ones, with the chips and cuttings, are made into varnishes and various compositions, or distilled for the oil.

Amber is found in hard brittle tears and lumps of more or less rounded, but often irregular, shape. They are round, usually small, rarely exceed a few grammes in weight, and vary very much in clearness and transparency. They often contain coarse impurities, vegetable remains, and dirt. Occasionally entire insects are beautifully preserved in them. The color of amber is generally yellow or brownish, but varies from almost white to nearly black; it is rarely greenish. The external or natural surface is usually rough or irregular, the interior often beautifully transparent. It is harder than most resins, has no odor or taste, breaks with a conchoidal fracture, and is capable of receiving a high polish.

It is insoluble in water and cold alcohol, but may be dissolved in boiling alcohol, benzol, etc. It softens at a moderately high temperature, but does not melt until 29° C., when it begins also to decompose. Composition, $C_{10}H_{16}O$, and hydrocarbons.

The use of amber itself in medicine is long past. It is sometimes an ingredient of fumigating powders or pastilles; directions also for making an ethereal tincture are in pharmaceutical works. The oil of amber (*Oleum Succini*, U. S. Ph.) is an empyreumatic liquid, obtained by dry distillation and purified by distillation from water. The crude oil is a mixture of hydrocarbons and acids; a thick, dark red, offensive smelling liquid. The redistilled is pale or white, "a colorless or pale yellow, thin liquid, becoming darker and thicker by age and exposure to air; having an empyreumatic balsamic odor, a warm, acrid taste, and a neutral or faintly acid reaction. Specific gravity about 0.920. It is readily soluble in alcohol," etc. (U. S. Ph.). It is extensively adulterated. Internally used—*dose*, two to five decigrammes (0.2 to 0.5 gm. = ♏iij. ad viij. = gtt. 5 to 15)—it is said to be stimulant and antispasmodic. Externally it is rubefacient, and is occasionally used as an ingredient of liniments. The residual pitch, "amber resin," left after the distillation of the oil, is dissolved to make a slowly drying, but very hard and durable varnish. Succinic acid is also one of the products of the disintegration of amber.

Allied Plants.—For other *Coniferæ* see Turpentine.

Allied Drugs.—Oil of tar is chemically and therapeutically analogous to oil of amber. Copal, kauri, and other fossil resins are strictly analogous products.

W. P. Bolles.

AMBERGRIS (*Ambre gris*, Codex Med.; *Ambra grisea*, *i.e.*, gray amber). A peculiar fatty material, found in lumps, generally on the surface of tropical seas; occasionally in the intestines of the sperm-whale, *Physeter macrocephalus* Shaw, where it is supposed to be a pathological formation. The balls are often of concentric structure, and in appearance and position are analogous to concretions found in other animals. Pieces vary in size from small fragments to great masses of fifty kilos or more (100 lbs.). It is a waxy, tasteless substance, crumbling, but also softening in the hand, having about the consistency of some gallstones, its color usually grayish or brownish, streaked or spotted with white. Odor slight, peculiar, not nauseous. At the temperature of boiling water it melts, and at a higher one is dissipated, leaving but little residue. Soluble in alcohol, ether, fixed and essential oils, etc.

Ambergris consists to the extent of about eighty-five per cent. of a peculiar non-saponifiable, crystallizable fat, *ambrein*, besides small amounts of extractive, benzoic acid, etc.

Ambergris has been used as an antispasmodic of the musk type, but is probably weaker than that. Its medical use is nowadays not worth serious thought. In perfumery, like musk, it has the property of holding and developing the vegetable odors.

The dose may be accepted as from one-fourth to one gramme (= gr. iv. ad gr. xvj.). A tincture would be a suitable form.

Allied Animals, etc.—Several species of whales and other *Cetacea* are hunted mostly for their oils, but none supply any medicines.

Allied Drugs.—A number of animal secretions have been reputed to have antispasmodic qualities. For a list of them see Musk. Among vegetable products *assafœtida, valerian*, etc., have taken the place which was formerly held by the others. See Assafœtida.

W. P. Bolles.

AMBULANCES AND THE AMBULANCE SERVICE IN LARGER CITIES.—Ambulance is a military term which is somewhat differently applied in different countries. It is probably derived from the Latin *ambulo,* "I walk" or "move slowly," because a gentle motion was necessary for the wounded. In France the term is applied to a movable hospital, *hôpital ambulant,* which is attached to each division of an army. The invention or improvement of this system, during the wars of the First Napoleon, is attributed to Baron Larrey. In England and America the word, as now used, signifies, "A two- or four-wheeled vehicle, which serves as a movable hospital for the wounded." Much study has been given to the construction of ambulances suitable for use during war, and great improvements have been made. During the War of the Rebellion the "Wheeling" and the "Rucker" patterns were principally used. When, subsequent to the establishment of peace, the subject of the introduction of the ambulance for service in New York City was presented, these vehicles were found unsuitable for the requirements of such a service, and an entirely different wagon was constructed. The army ambulance is built to convey a large number of wounded with the greatest comfort possible, from the place of immediate dressing to the place of permanent dressing, or operation; water, food, and stimulants, being generally all the requirements needed while *en route.* It was found that the ambulance for service in cities should be made lighter, to permit of speed; should have the body of the wagon lower, to increase comfort, and to allow of the bed being

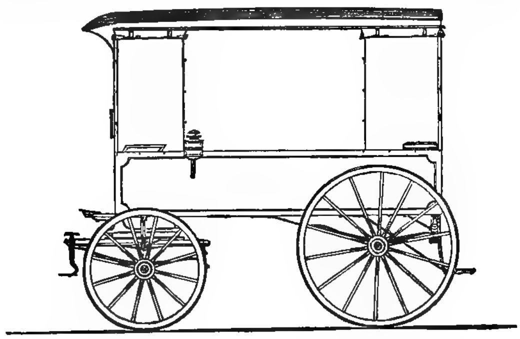

FIG. 81.—Abbot-Downing Company's Ambulance.

drawn out, and inclined to the pavement at as slight an angle as possible; should have the fore wheels turn under an arch in the body of the wagon, so as to permit placing the horse out of the way of passing vehicles, when the ambulance is backed to the curb, awaiting a patient, and also to allow turning the wagon in the narrower thoroughfares. Again, experience showed the importance of carrying in the vehicle surgical and medical appliances of all kinds, to meet the everchanging character of cases presented. After fifteen years of study by the surgeons and carriage-makers of New York, who are interested in the improvement of this service and its appointments, an ambulance has been produced which meets all the needs of city service. I speak concerning New York, for so far as I have been able to discover, with one exception, the few ambulances worthy of notice which have been constructed in other cities are close copies of this vehicle. The one exception is the design of Messrs. Atkinson & Philipson, of Newcastle-on-Tyne (see *Scientific American,* June 7, 1884). This ambulance does not, from the description given, add anything to the American model. It seems to be too heavy, its closed compartment too confining, and its wheel stretcher arrangement unnecessarily complicated. The popularity of the present patterns of ambulances constructed in New York is proved by the great number which have been built here and sent by the manufacturers from this city for service in other localities. I find that they have shipped them within a short time to the following places: London and Bristol, England; the Panama Canal Company, Panama; Guatemala; and the cities of Boston, Charlestown, Springfield, Brooklyn, Williamsburg, Albany, Buffalo, Cleveland, Chicago, Cincinnati, Charleston, San Francisco, Philadelphia, Washington, New Orleans, and Baltimore.

The first vehicle used in New York was the four-wheeled covered "market wagon." In this a mattress was placed, with pillows and blankets, and the limited supplies were carried in a bag or placed in a box. It was found that the motion of the wagon was objectionable, that the mattress soon became hard, and it and the bedding soiled and tenanted. The Fielding Brothers made the first improvement toward an acceptable ambulance. Mr. M. Curley, who was later wagon-builder to the Depart-

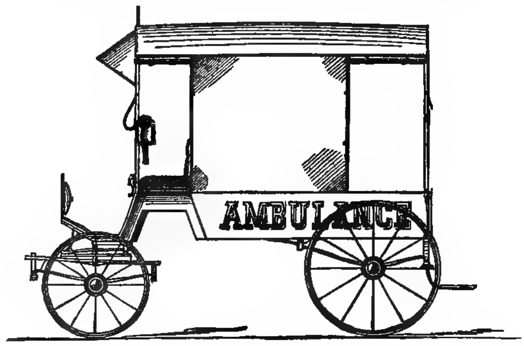

FIG. 82.—Bellevue Hospital Ambulance.

ment of Charities and Corrections, being asked to provide a vehicle more suitable for the uses of the Hospital, found it impossible to alter the old "sick wagon" for such service, and a short time afterward delivered by order to the department an ambulance which met with favor. From time to time improvements upon this have been made. At the present day there are three patterns or styles, either of which, except during the winter when the presence of snow in the streets impedes travel, is easily and rapidly drawn by a single horse. The internal fittings and supplies being nearly the same, the patterns approved by the different hospitals depend much upon the service which it is their duty to perform. Fig. 81

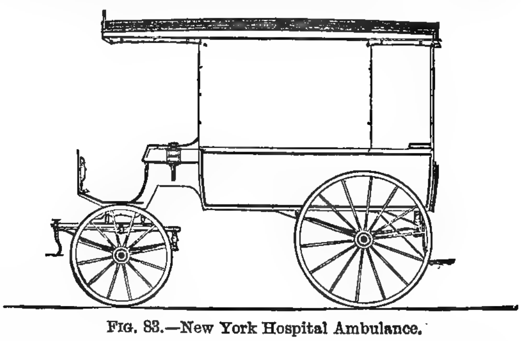

FIG. 83.—New York Hospital Ambulance.

represents an ambulance built by the Abbot-Downing Company. This style was formerly used at Bellevue Hospital, and still is in service at some institutions. It is the earliest model of ambulance, having a box body, the driver's seat inside, and only a rest for his feet forward. It cannot be turned easily, and is rather too high and too short for the comfort of the patient. Its advantages are its lightness (weight, from 800 to 1,000 lbs.) and the fact that it is not so expensive as the more elegant patterns (cost, less than $500). This vehicle is suited to a service where the streets are macadamized, or well paved, where the roads are wide, the distance to travel long, and where collisions with other vehicles or objects is improbable. The lightest ambulance yet made weighed 675 lbs. Figs. 82 and 83 represent two other varieties of ambulance, the

first, Fig. 82, constructed by Mr. M. Curley and used by the Bellevue and some other hospitals; the second built by the Abbot-Downing Company, and adopted by the New York and Chambers Street Hospitals. At first view these seem to be very much alike, and they are so, except in respect to the arrangement of the parts in front of the arch, in the construction of the driver's seat and hood, and in the attractiveness of outline. Either one will weigh from 1,100 to 1,300 lbs., will cost in the neighborhood of $600, and will meet the modern requirements of a serviceable ambulance. Naturally, each manufacturer claims a superior quality of wood used or a better make of springs or wheels for his vehicle, and each ambulance has minor points of superiority or inferiority, according to the nature of the service which it will have to perform. The further description of the ambulance will refer to these two patterns.

It has been the effort of the builders to produce a vehicle which would be distinct in character, and not resemble the so-called "Black Maria," which is used to transfer those suffering from contagious diseases, and is therefore avoided by the public; the "undertaker's wagon" which, at least, is not a cheerful looking object; and the "business delivery wagon" which does not inspire the drivers of other vehicles with respect. As the "right of way" is given by law to the ambulance, it is of advantage that it should be easily recognized in the crowded thoroughfares, and as the most aristocratic neighborhoods are often traversed by it in response to summons, it should be attractive, rather than an object offensive to the eye, or one warranted to arouse, through an attempt to conceal the contents, a suspicion of contagion. These considerations, however unimportant they may seem now that public confidence has been established, were at one time of weight.

It is hardly necessary to go into the details of the construction of the running gear of these wagons, as the pictures presented show as well as words could describe, their build. The length of the body is more than sufficient to permit of the patient lying on the bed, and gives room for the feet of the surgeon, who sits on a seat in the rear; it is wide enough for two patients to lie side by side without interference. The front box gives room for the driver and a seat for one patient. Eight persons can be carried should occasion require; one sitting with the driver, three lying upon the bed (one having his head to the rear and the other two with their heads forward), two sitting on the surgeon's cross-seat, supported by straps in the rear, and the surgeon riding upon the step which hangs down from the back end of the body. The driver's or forward seat, over the arch, is made wide, the cushions and top lift up on hinges, affording, in the box underneath, a receptacle for dressings, splints, etc. The floor in front is raised at an angle to give a firm rest for the feet, and to admit of the working of the lever by one foot of the driver, which rings the gong seen on the dashboard. In a pocket at the side of the dash-board is a leather apron for use in rainy weather. The surgeon's seat is a padded cross-board at the rear, firmly fixed to one side of the body with hinges, and at the other side secured by a catch. This seat can be raised at one end when the ambulance is opened, and the catch is caught in the side of the roof, thus keeping it perpendicular and out of the way. The rear end of the box or body is then unfastened at each side, and being hinged to the floor falls down against the rod of the surgeon's step, thereby admitting of free access to the interior. The sides and rear of the ambulance are furnished with adjustable leather curtains, though the centre panel at the sides is frequently made of wood. The roof is of hard wood. Upon each side and the rear end of the body, the name "Ambulance" is painted in large letters; this word is again conspicuously placed on a board running crosswise at the front of the roof. The lamps are placed at the sides, and sometimes a more powerful reflector has been attached to the centre of the roof in front. The surgeon's step is a wide, wooden platform, hanging down from the floor by rods at the rear, and allows of the surgeon entering or leaving the wagon while it is in motion, strong straps being placed at either side, firmly fastened to the rear roof-supports near their middle, to assist him in controlling his movements. The colors used in painting are generally black and dark green. The mountings and metal work of the body are painted, nickel-plated, or made of brass. When everything movable is taken from the inside of the ambulance, the floor, which is of wood, will be seen to have set into it two smooth iron strips about three inches wide, running from end to end, one on each side; this is the track on which the rolling bed is placed. The sides of the body are padded and covered with enamelled leather or gum cloth; to the rear of the driver's seat is an iron frame made to hold the medicine-chest; at one side is another frame to receive a box containing antiseptic dressings and instruments. Near the roof are straps for the reception of thigh-splints, and further back there is an ingenious arrangement to hold the surgeon's lantern. When in this condition the whole interior can be thoroughly washed and disinfected. The "fitting up" of the ambulance consists in placing the rolling bed upon its floor, preparing this for the reception of patients, and stowing away, in a convenient and compact manner, the medical and surgical supplies. The rolling bed consists of a frame made to fit the floor of the ambulance. Mortised into its under side, so as to rest upon the iron track before mentioned, are a number of small iron wheels, admitting of the bed being easily rolled in or pulled out from the body of the vehicle; when the bed is withdrawn, its rear end is lowered to rest at an easy angle on the ground, while the front end remains within the back part of the ambulance. On this frame bed, covering it entirely, is constructed a spring and hair mattress, higher at the middle than at the sides (to permit fluids, etc., to run off), and covered with gum cloth for cleanliness. At the front or head is an elevation which serves as a rest for the pillows, and prevents their sliding forward. After the patient is placed upon this bed (which is not taken out of the ambulance except to be cleaned), and comfortably covered, the rear end, which is provided with handles, is lifted to the level of the floor, and the couch is rolled, without jarring the patient, into its place. The latest pattern of bed has, at its forward end, heavy clamps which catch in rings at the rear of the ambulance when the bed is rolled out, thus preventing its falling entirely out should the horse start. These are so strongly made, that lately an ambulance having started when the bed—on which was a patient weighing 200 lbs.—was out, the lower end of the bed did not strike the ground, and the patient was held only by the clamps. A further addition is an adjustable support or legs for the rear end of the bed, so that it may not rest on the walk, but be placed at such an angle as may seem most desirable. Each wagon is provided with one or more stretchers; on these the patients are brought to the ambulance, and, still remaining on the stretcher, are laid upon the bed, thus being ready for removal when the hospital is reached. These stretchers each consist of three pieces of heavy canvas of equal size, the ends of which being turned over and firmly stitched down, leave a "sleeve" through which poles are passed; the three pieces being placed one after another on these two parallel poles, which extend far enough beyond for handles, furnish a convenient and strong litter on which to carry the patient from the scene of accident. Two iron crossbars, having rings to admit the poles, are used to extend the stretcher. The canvas is divided into three pieces for the comfort of the patient when the stretcher is taken from under him. In doing this the poles are first withdrawn, the head is raised, and one piece slid out; next the pelvis and then the feet are lifted, and the other sections are in turn removed, so that without disturbing the patient to any great extent, the orderly at the hospital can place him in bed. Two or more pillows and double blankets are carried; these should be frequently changed and disinfected. The supplies, consisting of medicines, instruments, and surgical appliances, are stored in their appropriate receptacles. Under the driver's seat are placed long and short coaptation splints in pairs; right and left tin arm-splints,

special splints, cotton in rolls, prepared jute, bandages of all widths and lengths, sheet lint and unbleached muslin, rubber tissue, a can of dressing for burns, sufficient to treat a number of cases, and sometimes a strait-jacket and stomach-pump. In the medicine chest, which is carried in an iron frame behind the driver's seat, and which is easily lifted out, and brought by the attendant to any place designated by the surgeons, the drugs are stored, each bottle being plainly marked and fitted into a tray to avoid breaking. Here are found emetics for use in poisoning, antidotes of every kind, styptics, heart stimulants, anodynes, anæsthetics, vaseline, and oil. In a smaller wooden box, placed on a similar frame at one side of the ambulance, are stored antiseptic dressings, hermetically enclosed, for use in wounds perforating cavities of the body, and antiseptic solutions for washing or irrigation. Instruments were sometimes kept in this box, but as those needed by the ambulance surgeon are few, and when wanted are required immediately, they are more frequently carried in the satchel which the surgeon keeps in his possession. Hanging in leather straps, close to the roof, are long and short thigh-splints, different varieties being approved by different hospitals, the best probably being provided with an adjustable foot piece and having rubber bands for extension and counter-extension. The satchel is marked with the name of the hospital on the outside, and contains usually, a pocket-case, hypodermic syringe, tracheotomy tubes, rubber tubing, a Nélaton's probe, a syringe, tourniquet, catheters, dressings for minor injuries, a bottle of antiseptic solution, stimulants, such as brandy and nitrite of amyl, morphine, ergot, a pocket street-directory, and an official list of the location of fire-alarm boxes. The surgeon's lantern is of that variety which can be carried on the arm; it is hung on a hook when in the ambulance, and is kept in place by a spring clamp at the side of the vehicle. A second inside light is useful, so that the driver may have light to find articles should the surgeon send for them.

The manner of hitching the horse or horses to the ambulance has been greatly improved since the swinging harness, as furnished by C. L. Berry, of Boston, has been generally adopted. This is similar to that used by the fire department. If a single horse is employed, the harness is attached to the shafts, excepting only the head stall, which is kept on the horse. By an arrangement of spring hooks, pulleys, and ropes, the harness, together with the shafts, is raised from the floor, at nearly an angle of sixty degrees, for the reception of the horse. As soon as the trained animal has taken his proper place, it is necessary to pull down the shafts, which causes the harness to be unloosed and fall into place on the horse, to spring the adjustable collar and hames together under the neck, and to fasten by snaffles the lines into the already-placed bit in the horse's mouth. This can be accomplished, after practice, in a few seconds. The advantages are, first, the horse is relieved of harness while in the stable, which, particularly during hot weather and at night, is desirable; second, the leather and trimmings can be cleaned with care and without disturbing the horse, as was impossible when one animal was always under harness; third, the time saved in "hitching up," compared with the best arrangement of the old style, is worth the additional expense.

The stable for the service requires a few words. It should be so located as to give a straight road or way to the street, and as near the surgeon's quarters as possible. It should be so arranged that the driver and horse on duty *alone* should be disturbed by a summons, and the opening of doors, etc., should not affect the entire stable by the admission of cold air. This requires that the floor should be divided into two distinct portions, the front being the ambulance room, and the rear the stable proper. The ambulance and horse, or horses, ready for duty should be placed in their separate room, the horse-stall being at one side and behind the ambulance. The advantages of this are twofold; first, the varnish on the ambulance, soon affected by the ammonia rising from a stable, is protected, and the communication of the odor to the bedding is avoided; second, the horse, or horses, for duty are placed in a working stall and unloosed by electricity when the gong rings. Horses, in this service, often become nervous, but if trained to know their place, those in the stable proper will not move when the bell rings, while the same animals, when placed in the ambulance room, will instantly run into place. Two horses are necessary for a single ambulance service, and at least three for the readiness of two vehicles; accidents, sickness, and shoeing generally keeping one animal more or less out of condition. The number of surgeons, drivers, and stablemen needed is a matter for the action of the authorities having supervision. The New York Hospital has lately established, at its Bloomingdale Hospital farm, a stable for the preparation of horses for this service in its branches in the city of New York.

The changes that may be made in a vehicle for ambulance service cannot be foretold; yet at the present time there seem to be only two points assailable, viz., the probable improvement of springs for the ambulance or for the bed, and the possible adoption of rubber tires for the wheels. These have been tried, without satisfaction, in this city. Dr. Robert Lawson, Inspector-General of Hospitals, England, writes in *The Lancet* (July, 1884, page 96), an article on the "Construction of Appliances for the Removal of Sick and Wounded." After reviewing the latest improvements in army ambulances, the Locale and Evans, and considering the introduction of springs inside the wagon for the stretchers to rest on, he concludes: "It is obvious that a man severely wounded is more advantageously situated when he is subjected to the motion of the body of the wagon alone, at a point as near the floor as can be managed, and the ease of this motion can only be adequately provided for by careful adaptation of the springs to the weight they have to carry."

The question of the disinfection and sanitary condition of the ambulance has been brought forward, and it has been shown how the ambulance of the present form can be thoroughly cleaned and rendered aseptic. These measures and the use of cleanliness in supplies will, under all common circumstances, be found adequate. Most ambulance surgeons have sat behind many contagious cases, but we have yet to hear of a single surgeon by whom the disease was contracted. This might be more easily possible were the vehicles closed. The Johns Hopkins Hospital, in its prospectus, advises an ambulance of "iron skeleton frame, with linings of wood and leather, which can be easily removed, being divisible into several parts. The litters should be iron wire mattresses. The lining should be frequently removed, and it and the ambulance wagon often disinfected by fumigation." If contagious cases were generally carried in the ambulance, it would be well to spare the time to follow this plan; but, except where the symptoms call for instant action, as in patients requiring tracheotomy in diphtheria, etc., such cases belong to the Health Department, and should be sent in a special wagon to the hospital for contagious diseases; thus avoiding the risk of contaminating the ordinary ambulance and insuring the public against contraction of disease through this channel.

Historical Sketch.—The origin of a City Ambulance Service, beyond doubt, is correctly credited to the city of New York. The history of the conception of such a department and its establishment, has up to this time never been fully written. From what can be learned, the idea of a "city relief service for the wounded," had been in the mind of Dr. Edward B. Dalton from the time when he became Sanitary Superintendent of the Board of Health, in 1866, until the time when he made the report which is referred to farther on. Dr. Dalton was commissioned in 1861 a Surgeon of Volunteers in the United States Army. Later he became the Medical Inspector of the Department of the Potomac, and having established, organized, and conducted the celebrated Depôt-Field Hospital of the Army of the Potomac, was, by the President of the United States, breveted Lieutenant-Colonel and Colonel of Volunteers. It is not surprising, therefore, that one who had had

thousands of wounded under his care, and had superintended and provided for their transportation, should originate the idea of a city ambulance service, when he became a municipal officer. The story of the first suggestion of a service of this kind, related by the Hon. Jackson S. Schultz, of New York, at that time (1868) President of the Board of Health, is as follows: "One day, while present at the old New York Hospital, then situated in the central part of the lower city, a sea captain, who had been severely injured on shipboard, was brought from his vessel to the receiving ward; he was suffering more from the rough manner of transportation than seemed necessary and, until his arrival at the building, had received no expert medical attention. In the presence of some members of the attending staff, Dr. Dalton spoke to this effect: 'The ambulance service of the army could be so modified in a city as to give such cases aid at the place of accident, and convey them comfortably to some institution for immediate surgical attention.' He was invited to present his ideas to the Staff of the New York Hospital. Whether this was done or not, it is impossible from the records to state, but it is said that he did make an oral report." The minutes of the Governors of the New York Hospital, at a meeting held February 23, 1869, show the following resolution, which would suggest that such a report had been made, probably to the Visiting Committee: "Resolved, that the Visiting Committee be requested to procure for the use of this hospital an ambulance of the most approved construction." About this time the New York Hospital disposed of their property in the lower part of the city, and nothing was done under this resolution. On May 1, 1869, the Department of Public Charities and Correction wrote, through their commissioner, a letter to Dr. E. B. Dalton, Associate Surgeon, in reference to the establishment of a Reception Hospital, for which a bill was pending in the Legislature of the State of New York, requesting him, in view of the probable passage of the bill, "to frame a Code of Rules suitable for the contemplated hospital, and *especially* for an ambulance system for the prompt and careful removal of the sick and wounded." On May 5th (see report of Commissioners of Charities and Corrections, 1869, p. 288) Dr. Dalton submitted in answer a document giving full particulars as to the best mode, in his opinion, of establishing the hospital, and of conducting the ambulance service. This paper is divided under these heads: First, Receiving Depot; second, Officers and Employees; third, Materials; fourth, Provisions and Rules for Transportation; fifth, Duties of Officers at Receiving Depôt. After the submission of this paper, and at the same meeting, it was resolved by the Board of Public Charities and Corrections: "That the city be divided into two surgical districts for the care of casualty cases," and the following rules were adopted:

"I. There shall be provided at Bellevue Hospital two ambulances of the form recommended by Dr. E. B. Dalton in his report of May 5th, and it shall be the duty of the warden to see that they are at all times in good order and fit for service; also two horses, one of which shall always be in harness, and ready to be attached to the ambulance; two drivers, one of whom shall always be on duty; two helpers, one of whom shall always be on duty.

"II. Each ambulance shall have a box beneath the driver's seat containing:

"1. One quart flask of brandy.
"2. Two tourniquets.
"3. Half dozen bandages.
"4. Half dozen small sponges.
"5. Splint material.
"6. Pieces of old blankets, for padding.
"7. Straps of various lengths, with buckles.
"8. Two-ounce vial of persulphate of iron.

"III. The bed of each ambulance shall be composed of two stretchers or litters (with iron handles and shoulder-belts at each end) sliding readily in and out on small rollers, and held firmly in place, when in, by spring snaps, or bolts." Articles No. IV., V., VI., VII., and VIII., which follow and complete the resolutions, refer to the administration of the service, and the contemplated co-operation of the Police Department. On June 1, 1869, the Police Department reported by letter from James H. Kennedy, Superintendent, that they would do everything within their power to make the service a success. On June 30, 1869, Dr. A. L. Loomis, Attending Physician to Bellevue Hospital, reported to the Commissioners of Charities and Corrections the fact that an examination for ambulance surgeons had been held, and two successful candidates were recommended for duty. On October 13, 1869, a request was received by the Commissioners of Charities and Corrections for a telegraphic connection between the Eighteenth Precinct of the Police Department and Bellevue Hospital. In the fall of 1869 (page 719 of report of Commissioners of Public Charities and Corrections), among the estimated expenses of the year to follow, was included $4,716 for an ambulance service. On December 2, 1869, the ambulance service was established in New York at Bellevue Hospital by the Hon. Thomas S. Brennan, then Warden and Commissioner. It was soon recognized as a necessity, and the favor which it has received from the private hospital corporations and the public is shown in the following table, which is compiled from official reports from the several hospitals named, giving figures until the expiration of the year of service in 1884.

RECORD OF THE AMBULANCE SERVICE, NEW YORK CITY.

HOSPITALS.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	Date Established.	Number of Ambulances.
Bellevue	74	1,466	1,275	1,482	1,484	1,020	1,846	1,610	1,217	1,606	1,888	1,858	2,282	2,008	2,813	Dec. 2, 1869.	6
Ninety-ninth Street	......	......	......	......	......	......	......	......	......	......	......	......	......	......	827	Nov., 1871.	2
New York	......	......	......	......	......	......	......	......	480	651	585	1,178	1,154	1,091	1,569	April, 1877.	2
Chambers Street	......	......	......	......	......	......	......	978	1,155	1,253	1,321	1,992	2,203	2,124	2,345	——, 1876.	3
Roosevelt	......	......	......	......	......	......	......	......	61	273	291	288	352	736	815	Sep. 12, 1877.	2
St. Vincent's	......	......	......	......	......	......	......	......	......	......	823	1,166	1,387	1,400	1,430	Jan. 1, 1879.	2
Presbyterian	......	......	......	......	......	......	......	......	......	......	......	276	387	507	614	July 5, 1880.	2

The record of service at the Ninety-ninth Street Hospital cannot be obtained previous to 1883. The increase of calls responded to from 1873, 1,484, to 1883, 10,413, is remarkable. The number of vehicles has been raised from two to nineteen. During the year 1883 the average time reported by the superintendents required to hitch and start varies in the different institutions from thirty seconds to two and one-half minutes. The time per mile in the business portion of the city is reported as five to eight minutes; in the less crowded thoroughfares, three and one-half to six minutes. The number of fire calls responded to during the year was 27 at the New York Hospital, 29 at Roosevelt, 60 at Bellevue, and 63 at St. Vincent's. Chambers Street has no separate list, and the fire-gong signal is new at the Presbyterian.

From this compilation it is evident that the City Ambulance Service has become of great value in the humane care of the injured in New York City. To facilitate the execution of the duties of those connected with the service, the following Act, relating to ambulances, was passed in the State Legislature of New York, April 16, 1879:

"Section 1. Every ambulance or other vehicle used for the transportation of sick and wounded persons or ani-

mals shall be entitled to the right of way over all other vehicles upon every public street, highway, and place. Any person who shall wilfully interfere with, or retard, or obstruct, or impede the progress of any such ambulance or vehicle thereon, or who shall wilfully injure the same, or wilfully drive any vehicle into collision therewith, shall be guilty of a misdemeanor.

"Sec. 2. All police officers, sheriffs, and constables shall, when called upon, aid the persons in charge of such ambulance or vehicle in placing sick or wounded persons or animals therein, and in the enforcement of the provisions of this Act.

"Sec. 3. Nothing in this Act contained shall affect the existing right of way of the United States Mail, or of the officers, men, and fire apparatus of any municipal fire department or insurance patrol."

By this Act, which obtained recognition on the part of drivers of vehicles in the crowded thoroughfares of the city of New York only after a considerable lapse of time, the ambulance was enabled to reach the scene of accident without delay. The bell-gong, to inform (by its ringing) the drivers of other vehicles to clear the way, and the police to aid the passage of the wagon, was found necessary to facilitate transit, and has now become a recognized feature.

At the present time the ambulance service of the city of New York is performed by both public and private hospitals, these having each been given certain precincts by the Police Department, and a limited numeral list of calls by the Fire Department, to which they respond individually. A call for a number of ambulances, having its regular summons by telegraph signal, is recognized in each branch, thus economizing the work of any one institution. Dr. De Forest Willard says in his appeal to the city of Philadelphia in 1883 for the introduction of ambulance service in that city: "The early arrival of professionally trained aid offers infinite advantages over the plan of depending upon the well-meant but injudicious effort of superficially and consequently dangerously educated helpers." For this reason, therefore, the "internes" of hospitals, who have won their position therein after severe competitive examination, and have served in the wards as assistant surgeons for some time, are detailed as ambulance surgeons in most institutions, they thus having gained full knowledge for the proper application of apparatus, and practical education for immediate diagnosis and treatment of the injured.

The method of service in the City of New York, which to-day may, perhaps, be taken as the most complete model in the world, is thus performed: A person is injured or sick; the attention of a policeman, or possibly a fireman, or citizen having the key to the nearest fire-alarm box, is obtained. If a policeman, the order for an ambulance is communicated, by messenger or by himself, immediately to his precinct headquarters; a telegram is instantly sent to the Police Central Office, and from there the hospital doing service in the neighborhood of the accident is notified. If the call is sent by the fire alarm telegraph (which is used only in case of urgent necessity), the nearest fire-alarm box is opened, and an ambulance call of twenty strokes and the number of the box are sent to the Fire Department Headquarters; this is repeated by them on all the gongs of the department in the city, both in hospitals and fire stations, and the institution required to respond to the call despatches its ambulance to the box indicated. At the hospital, the instant an ambulance call is recognized, either by telephone or "Morse" instrument from Police Central Office, or by signal gong from the Fire Department, an electric switch is turned which communicates with the stable, ringing the gong, unhitching the horse, opening the door, stopping the clock, and turning up the gas (if the call be in the night). The trained horse, now unloosed, runs into place; the driver pulls down the shafts, and clasps the patent collar and hames, attaches the reins into the bit-rings, and drives out. At the same time a bell in the ambulance surgeon's room has been rung. The attendant at the office writes on a prepared slip of paper the origin of call, the destination, and the time when received; this he places immediately on a rack in the passage-way most convenient for the surgeon, which rack contains the name of the party then responsible for the ambulance service. The surgeon who is ever ready for duty in the day-time, and at night is prepared to jump into his uniform in a few seconds, grasps his satchel, runs to the rack, obtains the written instruction, intercepts the ambulance as it is passing, gives the proper orders to the driver, and climbs into his place, seating himself in the rear of the vehicle. The time occupied from the first signal received at the hospital until the departure of the ambulance varies from twenty seconds to one minute. Quicker time has been made, though it is rarely necessary; delay being most frequently caused by the surgeon, who at the instant of call is engaged in ward duties.

At the seat of accident the members of the police and fire departments are always ready to aid in the care and preparation for transportation of the injured.

Upon arrival at the hospital, the orderlies remove the patient to the reception ward. The surgeon notifies the house-surgeon, and then enters, in an ambulance-book, a record of the call, giving time, place, name, diagnosis, cause of injury, and other particulars; the book being for the use of the public.

Having detailed the manner of performing the service in New York, it is well that I should speak of the

FIG. 84.—Transportation of the Injured.

changes and modifications which have been adopted in other cities. Up to the present time it seems that the value of this department has not been fully recognized in Europe. There is an ambulance service in some foreign cities, but the telegraph system is not used, and the necessity for rapid work is not appreciated.

In London Dr. Howard has succeeded in establishing the service in connection with a number of hospitals (see *British Medical Journal*, February 4, and March 4, 1882). In many of the manufacturing towns a service of some form is used, but the system of summoning the ambulance by telegraph or telephone is not generally adopted.

In Paris, according to the latest reports (see New York *Medical Journal*, March 15, 1884, and New York *Medical Record*, October 18, 1884), although Dr. Henri Nachtel after his return from New York set forth to the medical profession in that city the advantage of an ambulance service, and a representative body formally recommended to the municipal authorities the adoption of a similar service, nothing as yet has been accomplished. To give strength to his cause, Dr. Nachtel has lately secured the support of Victor Hugo. In a recent letter Victor Hugo expresses himself as follows: "New York has commenced, Paris will continue that which you propose, and which is suggested by reason, and by evidence. The success of the scheme will confirm your affirmations; it is clear, it is definite, it is humane."

Dr. James Whitson writes in the *Edinburgh Medical*

Journal, September, 1884, an article, entitled "The Ambulance Movement in Scotland." He gives the history of the establishment of the St. Andrew's Ambulance Association in 1882. He informs us that the ambulance wagons are now used in Glasgow, Edinburgh, and Coatbridge. The varieties of vehicles used in England and Scotland are shown by illustration of the "Coatbridge Ambulance," "The Atkinson & Philipson Wagon," and the first wagon of the St. John's Ambulance Association of London.

On the continent (elsewhere than at Paris) little progress has been made in the adoption of an ambulance service. This may be due to two reasons: first, the disinclination to adopt an American institution (as one writer on the subject in France has said, "I consider it highly descreditable to the country, the inhabitants of which assume to be in the van of progress and civilization, to be so exclusive and so adverse to foreign intervention, even when it affects their nearest interests"); second, there is not such a rivalry among charitable institutions as in this country, nor such a desire for cases as to induce the hospitals to voluntarily add to their expense in the maintenance of the system. I have been told—to illustrate this feeling—that one day an American student, being at one of the great hospitals in a continental city, saw a man injured in its immediate vicinity; he remarked to a professor, "If you had an ambulance system, that man would be cared for immediately." The answer was, "What difference would that make? the case *must* come to the hospital anyway."

In the United States the service has been adopted in nearly every large city. It is hardly worth while to mention their names here; the system of conducting the same is different, however, in places, and each seems to have its supporters.

In Philadelphia Dr. De Forest Willard has established the service in connection with seven hospitals, each having purchased ambulances, and two wagons having been lately ordered by the Department of Parks. The "Gamerrell system" is now being tested in several police districts, and is working satisfactorily. This is the placing of every square in the city in telephonic communication with the central station. The city appropriates $375 to each hospital which agrees to send an ambulance promptly to any point in its allotted district upon summons over telephone from a police station.

In Chicago the police telegraph service has the rendering "aid to the injured" under its care. The regular ambulance is used by some of the hospitals, but not by the city. The police wagon and ambulance combined responds to calls from street boxes. This vehicle is open and somewhat similar to the insurance patrol wagon; it is drawn by two horses, carries from four to ten policemen, contains a stretcher, handcuffs, lantern, blankets, medicine-chest, and coil of rope for use at fires. No surgeon accompanies this vehicle. A book of medical instruction for officers in charge of patrol and ambulance wagons, by Dr. F. Henrotin, Surgeon of the Police and Fire Department, is provided. Dr. Henrotin says: "You are simply to supply, as far as lies in your power, the place of the physician, and when he arrives are to follow his instructions, and render him what assistance you can." The alarm-boxes, of which there are several hundreds in the city, are placed in little houses similar to a sentry-box, having a lamp on top, thus taking the place of iron lamp-posts. These boxes, when open, reveal a signal-box with dials for different calls (criminal, fire, and accidental), and telephone for the use of patrolmen in communication with police stations. Keys to these boxes are numbered and widely distributed to citizens; a register of name being kept, to prevent false alarms. A key cannot be removed from the box, except by the ambulance-driver, who upon arrival releases it and returns it to the proper number.

In some cities the service is under the direction of the Board of Health, in others it is a private system, the ambulance being owned by individuals, and permitted to carry sick and wounded for hire, the city paying for the service.

The question, where the ambulance shall be stationed, is well answered by Dr. Willard, in favor of the hospital. He says, "The great value of the service lies in the prompt attendance of a skilled medical man, provided with appliances for the comfortable and speedy removal of the patient." That better men will be secured for this service by the hospital, rather than by the city, I think no one will deny. In the one case it will be a choice man, selected with care from a number of applicants, all of whom as a rule are the better members of the recently graduated medical classes. His associations and other duties will tend to make him a far preferable attendant upon the injured than would be the medical man, who, for a small salary, would spend his day at the station-house waiting for an ambulance call. Again, a patient arriving at a hospital in charge of one of its own surgeons is at once admitted, while, in the other case, a possible justifiable rejection might subject the sufferer to a longer journey before admission could be secured. It is a fact that the very best college men, the sons of many of our most prominent citizens, perform willingly for their hospitals, at the risk of health, and sometimes of life, the arduous duties of ambulance surgeon in New York. No compensation is expected or would be received by these devoted professional men. Yet it seems that some recognition should be made by the public, when through skill and heroism a life has been saved. This is hardly probable, however. The Humane Society does not follow the surgeon to the side of the patient, it does not recognize how necessary to the life of the patient was the operation so quickly and coolly performed. It overlooks the bravery in facing crime and contagion in the most uninviting portions of the city at all hours of the day and night. The ambulance surgeon can possibly gain encouragement from the peculiar motto of the Chicago service, "To save one good life is a greater blessing than to punish many criminals." *George W. Leonard.*

AMÉLIE-LES-BAINS, formerly Arles-les-Bains, is situated in the Department of the Eastern Pyrenees, near the town of Arles. Altitude, 222 metres (728 feet). The nearest railroad station is Perpignan, distant a little over twenty-three miles. The climatic conditions are so favorable that this watering-place has become a popular winter resort, especially as it also possesses hot sulphur springs. The mean temperature for the winter months (from November to March) is 9.55° C. (49° F.). Climatologically, therefore, it occupies a position midway between Nice and Pau.

There are four springs that deserve particular mention: the *Source du petit Escaldadon*, the *Source du gros Escaldadon*, the *Source Amélie*, and the *Source Manjolet*, the latter only being used internally.

The analysis of the Gros Escaldadon, as given by Poggiale, is as follows. In one litre (1,000 gms.) are contained:

	Gm.
Sodium sulphide	.012
Sodium chloride	.044
Sodium carbonate	.071
Potassium carbonate	.010
Sodium sulphate	.049
Sodium silicate	.118
Aluminium and ferrous oxide	.004
Organic matter	.009
Magnesia and lime	traces.
Total solids	.317

Temperature of the water, 62° C. (143.6° F.).

The mild climate and sheltered position of Amélie-les-Bains, and the excellent arrangements which its bathing establishments afford, render it a very desirable resort for patients suffering from diseases of the skin, rheumatism, scrofula, etc. It is found to be specially beneficial, however, in cases of chronic disease of the respiratory organs. The French Government, recognizing the merits of the place, has established here a large military hospital for the treatment of soldiers suffering from diseases of the chest.

Beside the military hospital just mentioned, there are two very large and complete establishments, which offer

every comfort and modern appliance that can be wished for. These are the *Thermes Romains*, supplied by the *Source du petit Escaldadon*, and the *Thermes Pujade*, supplied by the *Source Amélie*. The number of visitors during the winter is about six hundred.

Henry Fleischner.

AMENORRHŒA. Disregarding refinements of nomenclature, we may define amenorrhœa as a suspension or cessation of the menstrual function in a woman who is not pregnant and who has not reached the "change of life," or the period at which menstruation naturally ceases. The term should not be employed to include cases in which menstrual blood really exudes from the uterine mucous membrane (or from that of the oviducts, if we accept the doctrine that the Fallopian tubes take part in the function), but is prevented from making its appearance externally by some malformation, such as an imperforate hymen. It should be borne in mind that amenorrhœa is not in itself a disease, but simply a result of some morbid condition affecting either the system at large or some part of the genital apparatus.

Causes.—There is scarcely any derangement of the general health, especially if of a serious nature and chronic in its course, that is not prone to prove at least the predisposing cause of amenorrhœa. Usually, however, these deviations from health affect either the function of hæmatosis, the general nutrition of the body, or the normal action of the nervous system, and any two, or all three, of these disturbances may be combined. Moreover, it may be said that defective hæmatosis is itself a nutritive disorder, and that all irregularities of nutrition may take their origin in impaired nervous action. All this is true, but the practical utility of these distinctions remains, nevertheless. Of the particular diseases that give rise to amenorrhœa, the most noticeable are pulmonary consumption and chlorosis. In both instances, the suspension of menstruation seems to be a conservative effort on the part of nature to spare the system every unnecessary tax, and this consideration alone ought to be enough to teach us that it is not the re-establishment of the menstrual flow that we should aim at, but rather the restoration of the general health.

It has been doubted by good observers whether it is possible for a woman in perfect health to suffer from amenorrhœa, and there is much to sustain this position; but it is certain, nevertheless, that in many cases the impairment of the general health goes on for a long period without producing amenorrhœa until, finally, some additional factor comes into play, and may truly be looked upon as the exciting cause of the disorder. Among these exciting causes we may reckon almost all pelvic diseases, the functional perturbation consequent on exposure to cold during a menstrual period, emotional shocks, and traumatic injuries. It will be seen that these factors must vary widely in their mode of action.

Varieties.—Doubt has lately been cast upon the doctrine that the menstrual function is dominated by the ovaries, but it cannot be said that the doctrine has been seriously weakened, and we have, therefore, to distinguish, for purposes both of diagnosis and of prognosis, between amenorrhœa which is and that which is not due to failure on the part of the ovaries. In other words, concerning ourselves only with the mechanism, and leaving ultimate causes out of account for the time being, we have to distinguish between uterine and ovarian amenorrhœa. Practically, the only guide we have to a failure of that ovarian action which should serve to stimulate the menstrual flow, is the absence of the menstrual "molimen"—the *ensemble* of symptoms usually attendant upon the flow, including a sense of weight and pain in the pelvis, and in some cases pain, tenderness, and swelling of the breasts, with or without the various reflex disturbances that sometimes attend the menstrual effort.

The uterine variety is to be recognized by the state of the uterus, which will commonly be found to be one of atrophy (including the so-called "superinvolution") or of impeded circulation due to the contraction of old inflammatory exudates.

Diagnosis.—Amenorrhœa, as it is here defined, requires to be diagnosticated only from retention of the menses and from the physiological suspension due to pregnancy. The diagnosis will necessarily rest upon a physical examination, and for the details the reader is referred to the articles on Pregnancy, and on Retention of the Menses.

Prognosis.—The question of our ability to restore the menstrual function is to be answered wholly in the light of the causes on which its suspension is found to depend. Grave constitutional diseases, such as phthisis pulmonalis, imply the futility of all treatment in that direction, while the cure of the fundamental disorder may, on the other hand, be reasonably expected to be followed by the re-establishment of menstruation. As regards the local conditions, atrophy of the uterus and functional inactivity of the ovaries must give rise to an unfavorable prognosis, although temporary benefit may be produced by treatment in some instances. The prospect is better in the case of old inflammatory disease within the pelvis, for such affections are often amenable to treatment. In general, the causes will be found to be remediable, and, therefore, the prognosis favorable.

Treatment.—In the first place, the practitioner should avoid taking the patient's view of the matter—that she would "feel better if her courses would only come on." Women very commonly express themselves in some such phrase, and they apply to a physician under the idea that his art will bring on the menstrual flow promptly, and thus restore them to health. From what has been said of the causes of amenorrhœa, the reader will have inferred that any such expectation on the patient's part is likely to bring disappointment to her, and, if he allows it to go on, discredit upon himself, for, in all probability, he will not be able to meet the demand made upon him. It is better to give the patient to understand, at the outset, that her condition might be expressed more truly by a change in the phrase alluded to, namely, that her courses will come on when her health has been re-established.

Another caution needs to be given. Women who know or suspect themselves to be pregnant, frequently consult a physician in the hope that, in the attempt to bring on menstruation, he will really succeed in causing abortion. Whoever, under such circumstances, prescribes any measure, no matter how innocent, with the understood purpose of inducing the menstrual flow, is liable to have unpleasant charges brought against him in case abortion actually does take place, even as the result of some interference with which he had no connection. When called upon to undertake the treatment of a case of suppressed menstruation, it is prudent, therefore, for the practitioner to satisfy himself that pregnancy does not exist, and, in case of doubt, to decline the management of the case unless he can protect himself in some way, as by insisting that some trustworthy person be made acquainted with the facts at the start.

Having undertaken the management of a case in which treatment is sought for on account of amenorrhœa, a systematic inquiry should be made into the patient's state of health, and whatever deviation from the normal standard is found should be made the subject of treatment. For the details of such treatment, the reader is referred to the articles devoted to the various diseases that may be found. But, while insisting upon the general futility of measures addressed to the organs concerned in the menstrual function, without first attending to the general health, I must admit, nevertheless, that stimulation of those organs may be resorted to with some chance of success when no other indication can be made out; and, moreover, that, in cases where there are other indications at first, there often comes a time when the result aimed at may be hastened by measures that operate directly upon the pelvic organs.

There are but few therapeutic procedures that have a direct and unequivocal influence upon the function of menstruation, and, in so far as they tend to relieve amenorrhœa, those few act as local stimulants. The

so-called emmenagogues are not much to be depended upon, although we may admit that aloetics and chalybeates tend to produce a pelvic congestion favorable to heightened functional activity of the sexual organs. Their use, however, in the absence of other indications than the mere failure of the menstrual flow, is not to be recommended, although, if employed in conformity with such indications, they undoubtedly exert a certain influence. As a matter of fact, they are often indicated, and it is seldom improper to resort to them.

The preparations of manganese have lately been recommended by Dr. Ringer and Dr. Murrell, of London (*Lancet*, January 6, 1883). One-grain pills of permanganate of potassium may be administered, beginning with one pill three times a day, and increasing to two four times a day. The use of the drug should be begun three or four days before the time at which a menstruation should take place; and be continued, if the flow does not come on, until the time for the next period. It should be kept up also during the flow. Both the manganate of sodium and the binoxide of manganese are said to be equally effective, and it is stated that manganese acts as well with the plethoric as with the anæmic. It has been used to some extent in this country, and favorable results have been reported.

Electricity probably acts more directly as a provocative of menstruation than any other agent. Good effects may be produced by either the galvanic or the induced current, but the choice should not be a matter of mere caprice or convenience. Galvanism is more to be relied on for increasing the blood-supply of the uterus, while faradization is useful to intensify and precipitate the hæmorrhagic effort. To accomplish the latter purpose, the application ought to be made at a time when the degenerative changes in the endometrium have advanced to such a degree that heightened blood-pressure, aided by muscular action, may operate at the greatest advantage in producing rupture of the capillaries. This condition can be judged to be present only when there are some symptoms of ovulation, or when the amenorrhœa is of such recent date that the time for a menstrual flow to fall due is accurately known. In the use of galvanism, it will generally be prudent to place both electrodes on the external surface, unless the current is quite weak and the sitting a short one; aiming, however, to pass the current directly through the uterus. When the faradic current is employed, on the other hand, one electrode should be applied within the vagina, or even within the canal of the cervix.

Milder measures than the use of electricity will often succeed, especially where there is not complete absence of the flow, but scantiness and lack of color of the discharge. Among these measures, refrigeration of that portion of the spinal region corresponding to the motor centre of the uterus, is of great value. The skin over the junction of the dorsal with the lumbar vertebræ may be sprayed with ether three or four times a day, for five or ten minutes at a time, or ice-water compresses may be applied. These means are supposed to exert their effect by depressing the activity of the vaso-motor nerves. They are to be used only at the time when a menstrual flow is due. In the interim, an auxiliary measure of some value consists in the use of a very brief cold hipbath every night.

Frank P. Foster.

AMMONIA AND AMMONIC SALTS. 1. General Medicinal Properties of Ammonic Compounds.—Ammonic compounds, as a class, are irritant, locally, to a degree greater than that shown by the corresponding compounds of sodium, but less than in the case of compounds of potassium. They tend to be of high diffusion power, and are therefore, when swallowed, quickly absorbed, and hence are free from the purgative tendency of the low diffusion salts of potassium, sodium, and magnesium. Constitutionally they tend to increase the force and frequency of the heart's action and to determine a rise of arterial tension; to excite the "respiratory centre" in the medulla oblongata, causing fuller and more frequent respirations, and to enhance reflex irritability of the motor tract of the spinal cord—an enhancement leading in poisonous dosage in animals to tetanoid convulsions. General nutrition is not seriously affected by therapeutic doses. In long-continued excessive dosage the heart becomes enfeebled and the quality of the blood deteriorates, the hæmoglobin having its power of fixing oxygen notably impaired. An important difference between the alkaline ammonic compounds and the corresponding potassic, sodic, and lithic preparations is, that whereas the latter carry their alkalinity through the system generally and into the urine, no such effect follows the ingestion of the ammonic compounds. On the contrary, if anything, the acidity of the urine tends to be enhanced under ammonic medication. The explanation of this peculiarity among ammonic compounds is an assumed oxidation of the elements of the ammonic radicle, leading to the formation of nitric acid as one of the products. By virtue of the properties described, ammonic compounds furnish important medicines for restoring or sustaining flagging heart or lung action; for relieving dyspnœa, and for opposing the action of motor-paralyzing poisons.

2. The Medicinally used Ammonic Compounds.—These are ammonia, and the following ammonic salts: acid carbonate, acetate, phosphate, chloride, bromide, iodide, benzoate, and valerianate. In the present article will be discussed the first four only: for the others see respectively Chlorides, Bromides, Iodides, Benzoic Acid, Valerianic Acid. The sulphate and nitrate are also officinal salts, but for pharmaceutical purposes only.

Ammonia, NH_3. Ammonia is used in medicine only in aqueous or alcoholic solution, as afforded by the following officinal preparations of the U. S. Pharmacopœia: *Aqua Ammoniæ Fortior*, Stronger Water of Ammonia. This is an aqueous solution of ammonia, containing twenty-eight per cent., by weight, of the gas. It presents itself as a "colorless, transparent liquid, of an excessively pungent odor, a very acrid and alkaline taste, and a strongly alkaline reaction; specific gravity, 0.900 at 15° C. (59° F.). It is completely volatilized by the heat of a water-bath. On bringing a glass rod dipped into hydrochloric acid, near the liquid, dense, white fumes are evolved" (U. S. Ph.). From the volatility of its contained ammonia this preparation is directed to be kept in "strong glass-stoppered bottles, not completely filled, in a cool place." *Aqua Ammoniæ*, Water of Ammonia: "An aqueous solution of ammonia, containing ten per cent., by weight, of the gas." This weaker solution has the properties of the stronger, only not to so intense a degree. Its specific gravity is 0.959, at 15° C. (59° F.). It also should be kept cool, in glass-stoppered bottles, but the precaution to avoid filling the bottles completely is not here necessary. *Spiritus Ammoniæ*, Spirit of Ammonia: "An alcoholic solution of ammonia, containing ten per cent., by weight, of the gas." This solution is prepared by subjecting stronger water of ammonia, in a still, to a gentle heat, and conducting the ammonia gas thereby volatilized to a receiver containing freshly distilled alcohol. The product is assayed and brought to standard strength by the addition of alcohol. Spirit of ammonia is a "colorless liquid, having a strong odor of ammonia, and a specific gravity of about 0.810" (U. S. Ph.). It should be kept in glass-stoppered bottles, in a cool place. *Spiritus Ammoniæ Aromaticus*, Aromatic Spirit of Ammonia: This is a composite preparation, containing in 1,000 parts, carbonate of ammonium, 40; water of ammonia, 100; oil of lemon, 12; oil of lavender flowers and oil of pimenta, each, 1; alcohol, 700 parts; and the rest distilled water. It is a "nearly colorless liquid when freshly prepared, gradually acquiring a slightly darker tint, of an aromatic, pungent, ammoniacal odor, and having a specific gravity of about 0.885" (U. S. Ph.). This spirit, like the other ammonia solutions, should be kept glass-stoppered, in a cool place. But in spite of this precaution, the fact obtains generally with ammoniacal solutions that they lose strength upon keeping, so that a sample a year or more old may be almost wholly without ammoniacal odor. Ammoniacal solutions are incompatible with acids, acidulous salts, and many salts of the

metals and earths; ammonia, however, does not decompose calcic salts, nor, except partially, magnesic.

Ammonia is chemically a powerful alkali, and, physiologically, is in gaseous form intolerably pungent, its fumes, if strong, exciting vigorous spasm of the larynx. In strong solution, it is intensely irritant. Either of the officinal waters of ammonia, or the simple spirit will, if of standard strength, excite severe irritation upon incautious inhalation of the fumes, and, if applied to the skin upon cloths so covered as to prevent evaporation, will very speedily cause burning pain and redness, and, after a few minutes, blistering. Prolonged application may lead to ulcerative inflammation or gangrene. Internally, in proper dilution, ammoniacal solutions are locally alkaline so far as the contents of the stomach and bowels are concerned, and also, because of the pungency and volatility of ammonia, they tend to allay nausea and to expel flatus. Ammonia, being of high diffusion power, is readily absorbed, whether taken by swallowing or by inhalation, and then quickly but evanescently exerts the peculiar effects of the ammonic compounds upon the heart, respiration, and motor tract of the cord as already set forth. Undiluted, the three first named pharmacopœial solutions of ammonia are so irritant as to be practically corrosive to the mucous membrane of the stomach and bowels. Large doses are, therefore, violently poisonous, capable of causing speedy death, with all the usual symptoms of corrosive irritation. In some cases death results in so short a time as a very few minutes, probably from suffocation through rapidly developed œdema of the glottis. So small a quantity as about a teaspoonful and a half of a strong solution of ammonia, swallowed undiluted, has killed. Dangerous, and even fatal, poisoning has also resulted from inhalation of strong ammoniacal fumes.

The therapeutical uses of ammoniacal solutions are local and general. Locally, according to strength of application, ammonia may be made to serve as a vesicant or rubefacient. To blister, a pledget of lint, steeped in a strong solution, is covered with a watch-glass or wooden pill-box to prevent evaporation, and then directly applied. In such way the stronger water of the Pharmacopœia has been used, but this solution is unnecessarily and, unless very carefully manipulated, dangerously strong. If employed, the application should be held in contact with the skin for only three or four minutes, or until the part is well reddened, and should then be removed and a hot poultice applied until the blister rise. It is safer to dilute the stronger water with one-half its volume of additional water. Ammonia is rarely selected as a blistering agent, unless the need for the blister is urgent, when the quickness with which ammonia acts makes it preferable to cantharides. For rubefacient purposes a dash of the stronger water is a very common addition to composite liniments, and there is officinal in the U. S. Pharmacopœia *Linimentum Ammoniæ*, Ammonia Liniment, or as it is commonly called, *volatile liniment*. This preparation is made by mixing three parts of water of ammonia (not the stronger water) with seven of cotton-seed oil. An ammonia soap results, which partly dissolves and partly remains emulsified in the fluid, forming a white viscid mixture. The preparation is saponaceous, yet possesses mildly the irritant qualities of ammonia, and makes a capital liniment for rubefaction. Still a third local purpose of ammonia is to relieve the pain or itching of bites of insects. For this purpose a drop or two of the weaker water, clear or diluted, may be applied to the part. Internally, ammonia may be used, first, to correct the gastric malaise that attends a fit of acid indigestion, or to allay nausea from any cause. For such purpose the aromatic spirit is specially devised, to be given in doses of from one-half to one teaspoonful, diluted with three or four volumes of water. Secondly, ammonia may be given for the constitutional effects of reviving the heart in faintness, of supporting it in chronic conditions threatening heart-failure, of stimulating flagging respiration, as in dyspnœa from lung disease, or respiratory failure in poisoning by paralyzing agents, of allaying mild spasmodic seizures, and of opposing generally the action of narcotics and paralyzers. For all internal medication the stronger water is entirely too strong, and the weaker water or the spirits are preferred. Of this water or simple spirit from ten to thirty drops may be administered at a dose, largely diluted. If swallowing be impossible, as in case of unconsciousness from a faint, the effects of ammonia may be obtained by inhalation, but great caution is necessary lest dangerous, or even fatal, irritation of the air-passages be set up by too strong inhalation during complete or semi-unconsciousness. None of the pharmacopœial ammoniacal solutions should be applied close to the nostrils.

Acid ammonic carbonate, NH_4HCO_3. Upon subliming a mixture of chalk and ammonic chloride or sulphate, double decomposition ensues, and a sublimate is obtained which consists of acid ammonic carbonate and ammonic carbamate, represented by the symbol, $NH_4HCO_3.NH_4NH_2CO_2$. This composite salt is officinal under the title *Ammonii Carbonas*, Carbonate of Ammonium. It occurs as "white, translucent masses, consisting of bicarbonate (acid carbonate) of ammonium and carbamate of ammonium, losing both ammonia and carbonic gas on exposure to air, becoming opaque, and finally converted into friable, porous lumps, or a white powder (acid carbonate of ammonium). The salt has a pungent, ammoniacal odor, free from empyreuma, a sharp, saline taste, and an alkaline reaction. Soluble in 4 parts of water at 15° C. (59° F.), and in 1.5 part at 65° C. (149° F.).* Alcohol dissolves the carbamate and leaves the acid carbonate of ammonium. When heated the salt is wholly dissipated, without charring. If the aqueous solution is heated to near 47° C. (116.6° F.), it begins to lose carbonic acid gas, and at 88° C. (190.4° F.) it begins to give off vapor of ammonia. Dilute acids wholly dissolve the salt with effervescence" (U. S. Ph.). This salt must be kept in well-stopped bottles in a cool place.

Ammonic carbonate behaves, physiologically, like ammonia itself, but is a little less rapid and evanescent in operation. In concentrated solution it is locally irritant and, taken internally, dangerously poisonous. The salt is used for the constitutional stimulant and sustaining effects of ammonia, being for such purpose often preferred to solutions of ammonia because of the slightly longer duration of the action. It is given internally in frequently repeated doses of from 0.30 to 0.60 gramme (five to ten grains) in aqueous solution, with the acrimony disguised by gum arabic or sugar, or some agreeably flavored aromatic addition. Large single doses should be avoided, since they easily over-irritate the stomach and may excite vomiting. Ammonic carbonate is also much used to get an ammoniacal effect by inhalation. For this purpose it is coarsely bruised, treated with half its bulk of strong water of ammonia, and flavored with a little oil of lavender or bergamot, such mixture constituting what is known as *smelling salts*.

Ammonic acetate, $NH_4C_2H_3O_2$. This salt is used only in the aqueous solution in which it results from the procedure of neutralizing with ammonic carbonate the diluted acetic acid of the Pharmacopœia. Such solution, commonly called *spirit of mindererus*, is officinal as *Liquor Ammonii Acetatis*, Solution of Acetate of Ammonium. It is "a clear, colorless liquid, free from empyreuma, of a mildly saline taste, and a neutral or slightly acid reaction; specific gravity, 1.022. It is wholly volatilized by heat. When heated with potassa it evolves vapor of ammonia, and when heated with sulphuric acid it gives out vapor of acetic acid. It contains about 7.6 per cent. of acetate of ammonium" (U. S. Ph.). It should be freshly made for use, since like other solutions of alkaline salts of the common organic acids it tends to spontaneous decomposition on keeping. Ammonic acetate is a bland, mawkish salt, which upon absorption may prove feebly diaphoretic or diuretic, according to circumstances, and may to a slight degree exert the characteristic effects of the ammonic com-

* According to Squibb the salt begins to decompose at much less than this temperature.

pounds generally. It is used to allay headache, especially the headache of pyrexia, to quiet an uneasy stomach, or to promote gentle diaphoresis or diuresis in fever; but it is at best a feeble medicine. One or two tablespoonfuls may be given at a dose, clear or diluted, sweetened and aromatized. If diluted, carbonic acid water makes an excellent addition.

(Di-) Ammonic (ortho-) phosphate, $(NH_4)_2HPO_4$. The salt is officinal as *Ammonii Phosphas*, Phosphate of Ammonia. It occurs in "colorless, translucent, monoclinic prisms, losing ammonia on exposure to dry air, without odor, having a cooling, saline taste, and a neutral or faintly alkaline reaction. Soluble in 4 parts of water at 15° C. (59° F.), in 0.5 part of boiling water, but insoluble in alcohol. When strongly heated the salt fuses, afterward evolves ammonia, and at a bright red heat is wholly dissipated" (U. S. Ph.). Ammonic phosphate is a bland saline without any marked physiological properties, and has been used on theoretical grounds in rheumatism, gout, and diabetes, by a few practitioners, without very startling results. It may be given in doses of from 0.65 to 2.00 gm. (ten to thirty grains) three or four times a day in solution.

Ammonic nitrate, NH_4NO_3. The salt is officinal in the U. S. Pharmacopœia as *Ammonii Nitras*, Nitrate of Ammonium. It is not used in medicine, but inasmuch as one of its pharmaceutical uses may need to be availed of by the physician himself—namely, the making from it of nitrogen monoxide gas—the pharmacopœial description and also tests for purity are here appended: "Colorless crystals, generally in the form of long, thin, rhombic prisms, or in fused masses, somewhat deliquescent, odorless, having a sharp, bitter taste, and a neutral reaction. Soluble in 0.5 part of water and 20 parts of alcohol at 15° C. (59° F.); very soluble in boiling water and in 3 parts of boiling alcohol. When gradually heated, the salt melts at 165° to 166° C. (329° to 331° F.), and at about 185° C. (365° F.) it is decomposed into nitrous oxide gas and water, leaving no residue. The aqueous solution of the salt, when heated with potassa, evolves vapor of ammonia. On heating the salt with sulphuric acid it emits nitrous vapors. The aqueous solution, when acidulated with nitric acid, should not be rendered cloudy by test solutions of nitrate of silver * (chloride), or of nitrate of barium * (sulphate)" (U. S. Ph.).

Normal ammonic sulphate, $(NH_4)_2SO_4$. The salt is officinal in the U. S. Pharmacopœia as *Ammonii Sulphas*, Sulphate of Ammonium. It is used only in the pharmaceutical making of ammonia and iron alums.

Edward Curtis.

AMMONIA, POISONING BY.—The first symptoms of poisoning by ammonia, when the drug has been swallowed, are those due to the local action of the drug upon the mucous membrane of the mouth, throat, and stomach. There is intense pain in the œsophagus and abdomen, and the lips, tongue, and pharynx are swollen and reddened. Vomiting occurs soon, and the vomited matters often consist largely of blood. Purging sets in, and blood is passed also in the stools. There is a considerable degree of dysphagia. The pulse becomes rapid and weak, and respiration is greatly accelerated. There is cough, with increased secretion from the trachea and bronchi, and œdema of the glottis sometimes occurs. The intellect may be preserved to the end, or stupor may arise, passing into coma and death. The symptoms of gastro-enteric and bronchial inflammation are manifested almost immediately, and increase in intensity, reaching their maximum in the course of a few days. When poisoning has been produced by inhalation, there is spasm of the glottis, and consequent dyspnœa, often with aphonia. Œdema glottidis very commonly occurs, and all the respiratory symptoms are intensified, but those of the gastro-enteric system are absent, or very insignificant. The diagnosis of poisoning by ammonia presents no difficulty, owing to the characteristic odor of this substance. Poisoning has been caused by the ingestion of carbonate of ammonia, as well as of the aqueous and alcoholic solutions of the gas, but the chloride (muriate) of ammonium is practically of no toxicological importance.

Treatment.—The stomach-pump should never be used after poisoning by ammonia, for fear of doing further injury to the gastric mucous membrane. Dilute vegetable acids, vinegar, or lemon-juice, should be given at once, and then oily or mucilaginous drinks may be taken. The resulting bronchitis and gastro-enteritis are then to be treated on general principles. When the poison has been inhaled simply, the inflammation of the respiratory passages only will demand attention. In the dyspnœa resulting from œdema glottidis, tracheotomy may be necessary to preserve the patient's life.

Thomas L. Stedman.

AMMONIAC (*Ammoniacum*, U. S. Ph., Br. Ph., Ph. G.; *Gomme ammoniaque*, Codex Med.; *Dorema Ammoniacum* Don). The source of the above is a large, weird-looking umbelliferous plant, growing abundantly in the wastes of Persia and Beloochistan. It has a fleshy, turnip-shaped, perennial root, nearly thirty centimetres (one foot) in length, which is itself an article of commerce in the East, and known as "Bombay sumbul." The flowering stem does not appear until the plant is five or more years old; it is thick and coarse, two metres or more (over six feet) in height. There are a few large compound leaves at its base, but above it is leafless. It terminates in a large, close raceme, along the branches of which the minute flowers are clustered in small globular heads.

The plant is filled with an abundance of milky juice, contained in both stem and roots, which exudes either spontaneously or from punctures made by a beetle which feeds upon it. The sap, as it escapes, hardens and dries upon the stem, and flows or drops to the ground. It is collected in July and August, partly from the stems, partly from the ground, by Persian peasants, and exported to India, and from there to Europe.

Fig. 85.—Dorema Ammoniacum, Fruit.

Ammoniac consists of these hardened drops, or tears, as they are technically called. In the best qualities they are separate, or only loosely stuck together in porous masses; in inferior grades they are imbedded in a dark-brown resinous matrix. Fine specimens consist of rounded pieces from one millimetre to a centimetre or two (one-twenty-fifth to three-quarters of an inch) in diameter. They are brownish, cream-colored externally, darkening to cinnamon-brown with age, creamy white, or pure white within They break with a conchoidal fracture, disclosing a waxy, but shining surface. The odor is peculiar, rather disagreeable, but faint, excepting in masses or upon warming; the taste bitter and rather acrid. Inferior specimens are those having a large proportion of the darker homogeneous resins and extraneous substances, such as dirt, sticks, chaff, etc. It is a difficult drug to powder, unless very cold or very dry (dried over quicklime, Hager). When heated it softens, but does not melt. Alcohol dissolves about three-fourths of it. Water disintegrates it, and forms with it a milky emulsion.

Ammoniac consists of about seventy per cent. of resin, fifteen to eighteen of soluble gum, and the rest is insoluble gum, water, and a trace of essential oil. The latter, according to Flückiger, does not contain sulphur, and, therefore, is not similar to the oil of assafœtida.

Ammoniac is stimulant, expectorant, and to a slight extent said to be antispasmodic, but is scarcely used now internally. The dose is stated to be half a gramme to two grammes (gr. viij. ad gr. xxx.) three or more times a day. An emulsion would be an eligible form, although a tincture would probably contain all that was active in it. The only officinal preparation is Ammoniac Plaster (*Emplastrum Ammoniaci*, U. S. Ph.), made by softening the ammoniac in diluted acetic acid, and evaporating to a suitable extent. It is a stimulating and rube-

* Five per cent. aqueous solution (distilled water).

facient, sometimes blistering application, useful as a mild counter-irritant.

Allied Plants.—One other species of *Dorema*, according to the "Pharmacographia," yields ammoniac. Bentham and Hooker only include two species in the genus. The ammoniac of Dioscorides and Pliny, and other ancient writers, was obtained in Africa, and is a different article, namely, a gum resin obtained from *Ferula Tingitana* Linn. It is rarely found in European markets. *Sagapenum* is an obsolete product of a similar nature. See Assafœtida; also see Anise, for a notice of the order.

Allied Drugs.—See Assafœtida. *W. P. Bolles.*

AMNION. The amnion is a thin, pellucid membrane, which is the innermost of the envelopes enclosing the fœtus while *in utero.* Morphologically it is an extension of the body-walls (somatopleure) of the fœtus itself, and, therefore, consists, histologically, of two layers, one epithelial, continuous with the ectoderm (seu epidermis) of the embryo, the second of loose connective tissue continuous with the outer leaf of the mesoderm, which, after the splitting of the middle-germ layer, unites with the ectoderm to form the somatopleure. The epithelial layer is turned *toward* the embryo, and the connective tissue consequently lies upon the outside of the amnion, away from the embryo and toward the uterine wall.

The usual descriptions of the development of the amnion in mammalia are erroneous, in that the process is described as essentially the same as in birds, whereas it is essentially different, as has been recently demonstrated for the rabbit and bat by Édouard van Beneden and Charles Julin ("Arch. de Biologie," tome v., p. 369), and has been rendered very probable for man by Wilhelm His ("Anatomie Menschlicher Embryonen").

In birds and mammals, according to the tradition which has come down to us from Von Baer and Von Bischoff, the amnion arises in the same manner as in reptiles; we now know that this is true only of birds. In the sauropsida (birds and reptiles) the amnion grows up around all sides of the embryo; in the rabbit it grows up over the posterior end, and gradually presses forward until it covers the whole, or nearly the whole, embryo; in man it is supposed by His to grow up over the head and advance backward, but it must, in view of Van Beneden's and Julin's discoveries, be surmised that, when actual knowledge replaces supposition, the development of the fœtal envelopes in man will be found to conform more closely to the process in other mammals than now appears to be the case. In this article it has been deemed best to give a short account of the origin of the amnion, 1, in the chick; 2, in the rabbit; 3, in man, according to His's theory.

1. Amnion in the Chick.—The middle germ-layer divides very early into an outer leaf, which unites with the ectoderm to make the somatopleure, and an inner leaf, which unites with the entoderm to make the splanchnopleure; the space produced by the splitting of the mesoderm is the future body-cavity (cœlom), and is generally known as the pleuro-peritoneal space. The split extends beyond the region of the embryo proper over the surface of the ovum, hence there is a distinct somatopleure in the area around the germ, and this it is which gives rise to the amnion in all cases, both in birds and mammals. In the hen's egg, at about the twentieth hour of incubation, there appears around the anterior end of the primitive groove, which is the only embryonic structure distinguishable by the naked eye at that period, a large arch, Fig. 86, *vAf;* this semilunar fold is produced by the arching upward of the somatopleure. Somewhat later a second, but smaller, fold appears around the caudal extremity of the embryo, and this is soon followed by lateral folds, one on each side. Meanwhile the head fold has greatly increased in extension, and partly covers over the anterior end of the embryo, which has also advanced rapidly in its development. By the fusion of all the folds the embryo becomes enclosed in a thin somatopleuric duplicature, which forms a continuous wall all around it. The folds increase in height and are gradually drawn over the dorsal aspect of the embryo, and at last meet and completely coalesce, all traces of their junction being removed. Beneath these united folds there is, therefore, a space, within which the embryo lies; this space is the cavity of the amnion.

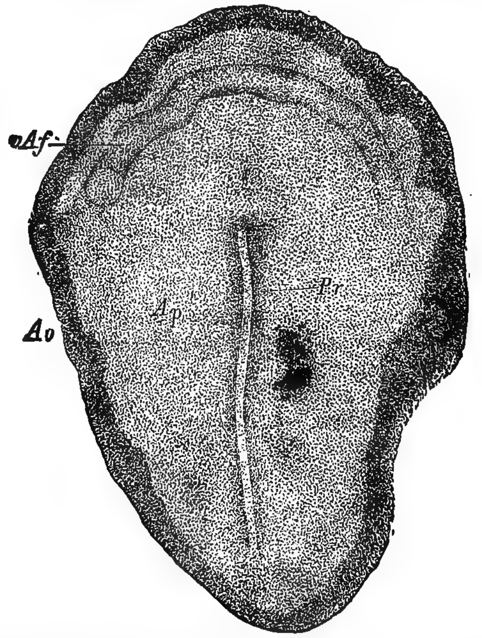

Fig. 86.—Area Pellucida of a Chick; Twenty Hours' Incubation. *vAf*, anterior amniotic fold; *Pr*, primitive groove in the area pellucida, *Ap*. (After Kölliker.)

The accompanying diagrams will serve to elucidate these changes; they are taken from Allen Thompson. In these figures the parts of the embryo, and those near it, are represented larger than natural in proportion to the rest of the egg. Fig. 87, *A*, represents a longitudinal section of a hen's egg and, therefore, a transverse section of the embryo; *sh*, is the calcareous shell, etc.; *sp*, the air-space at the larger end; *vm*, the vitelline membrane; *y*, the yolk partially covered by the spreading layers of the blastoderm, viz., *ep*, somatopleure, and *hy*, entoderm; of the mesoderm only the splanchnopleuric portion, *me*, is

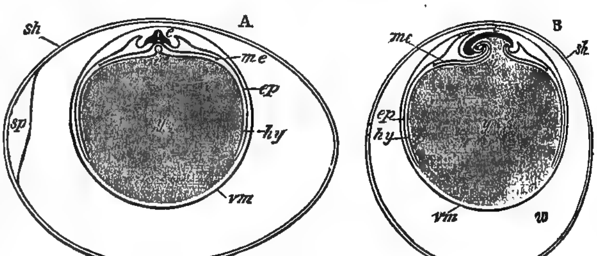

Fig. 87.

indicated; the embryo, *e*, is black; the rising lateral folds of the somatopleure are seen on either side of the embryo. Fig. 87, *B*, is a longitudinal section of an embryo of the same stage, to show the large size of the cephalic amniotic fold and its extension backward; also the lesser proportions of the caudal fold. Fig. 88 represents the successive steps in the development of the amnion; *A*, at the beginning; *B*, at the end of the second day of incubation; *C*, on the third day; *D*, on the fourth day. The embryo is black; the lettering is the same as on Fig. 87. The manner in which the meeting and the final coalescence of the folds is accomplished, is here very well shown. Another important point is likewise made plain by these

diagrams, viz., that the amniotic folds consist of two leaves, an inner and an outer leaf; so that after their coalescence there appear over the embryo two membranes, Fig. 88, *D*, the inner of which is the true amnion, *am*, and lies close about the embryo; from the mode of its formation we understand why the epithelium of the amnion, being the continuation of the embryonic epidermis, faces toward the embryo. The outer membrane, *D, ep*, passes outside the true amnion and over part of the surface of the yolk; it goes by the name of the false amnion, or membrana serosa of Von Baer; according to the text-books, it is vaguely said to participate in the formation of the chorion, and, indeed, current opinion is extremely confused in regard to the whole history of the chorion. In fact, however, the relations of the membrane and its homologies are quite evident and easily understood: *the false amnion is the equivalent of a part of the chorion of mammals;* the remainder of the mammalian chorion being represented by the layer of ectoderm and subjacent mesoderm on the external surface of the yolk. This interpretation, which is here published for the first time, appears to me incontrovertible.

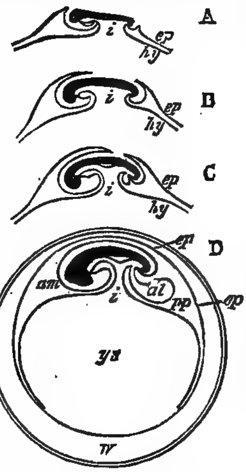

FIG. 88.

2. FŒTAL ENVELOPES OF THE RABBIT.—Very different is the arrangement of the amnion in the rabbit; it is shown in the accompanying very admirable diagram, after Van Beneden and Julin. In the higher mammalia, it will be remembered, the yolk substance has almost entirely disappeared. (In the monotremes, according to Caldwell,

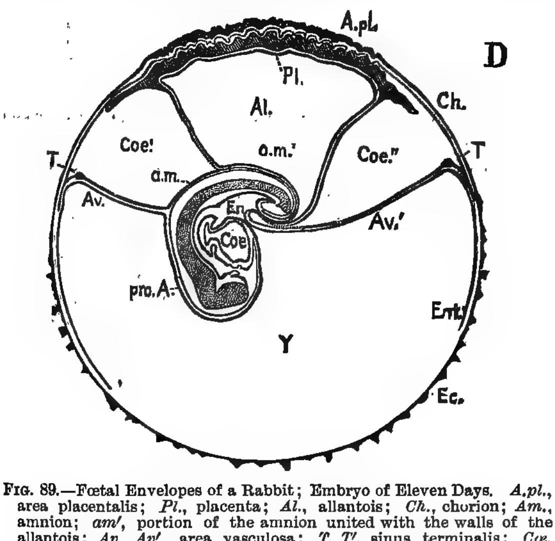

FIG. 89.—Fœtal Envelopes of a Rabbit; Embryo of Eleven Days. *A.pl.*, area placentalis; *Pl.*, placenta; *Al.*, allantois; *Ch.*, chorion; *Am.*, amnion; *am'*, portion of the amnion united with the walls of the allantois; *Av, Av'*, area vasculosa; *T, T'*, sinus terminalis; *Cœ*, cœlom, or body cavity; *Cœ', Cœ''*, extra embryonic portion of the body cavity; *En*, entodermic canal of the embryo; *Ent'*, entoderm of the blastodermic vesicle; *Y*, cavity of the blastodermic vesicle; *Ec*, ectoderm; *pro-A*, Proamnion.

it is still preserved.) In the placentalia, the yolk-sac is present as a vesicle of varying dimensions; in the rabbit, it is much dilated, forming (together with part of the original blastodermic cavity) a large space—the so-called cavity of the blastodermic vesicle, *Y*. This cavity, as is shown in the figure, communicates with the digestive canal directly; the walls of the vesicle are constituted by various layers; inferiorly is ectoderm only, while superiorly there is a continuous sheet of ectoderm; on either side of the embryo, and, in fact, completely around it, the entoderm is united with a stratum of the middle layer, thus making the area vasculosa, *Av, Av'*; the head of the embryo is bent downward, and has forced in part of the wall of the blastodermic vesicle. This invaginated membrane, *pro-A*, is called the pro-amnion, and in consequence of its peculiar developmental history is formed by the ectoderm and entoderm without any mesoderm between them. The pro-amnion has been usually mistaken for a part of the true amnion, *am, am'*. The allantois, *Al*, has a very large cavity; its outer wall is very much thickened to form the placenta, *pl*. The amnion covers only the posterior portion of the embryo, and is partly grown together with the wall of the allantois. After this stage, the pro-amnion, *pro-A*, gradually atrophies, the embryo protrudes less and less into the blastodermic vesicle, and in the same measure the amnion expands, spreading farther and farther forward over the front end of the embryo. The amnion, in earlier stages, arises as a fold of the somatopleure over the tail of the embryo. There appears to be no structure in the rabbit comparable to the cephalic amniotic fold of the chick. For further details in regard to the origin of the membranes in rabbits, etc., see Proamnion.

3. THE HUMAN AMNION.—The early stages of the human amnion have never been observed. His has

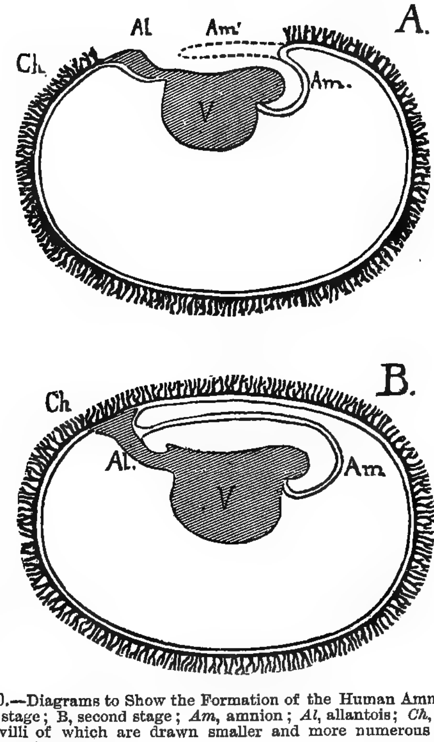

FIG. 90.—Diagrams to Show the Formation of the Human Amnion. A, first stage; B, second stage; *Am*, amnion; *Al*, allantois; *Ch*, chorion, the villi of which are drawn smaller and more numerous than in nature; *V*, yolk-sac.

studied an embryo of 2.6 mm., which showed, according to his description and interpretation, essentially the relations shown in Fig. 90, *B*. The embryo rested upon the large yolk-sac, *V*, and was connected by a short stalk, *Al*, with the chorion, *Ch*. The amnion arose under the head, at the junction of the yolk-sac and the embryo, passed upward around the head and back over the embryo, to join posteriorly the allantois stalk. To explain this disposition His has advanced the following hypothesis as to the course of development: The embryo arises upon the surface of the blastodermic vesicle; its tissues pass over into the external chorion for one part, and the internal yolk-sac for the other. The embryo

now sinks down, as shown in Fig. 90, *A*, toward the centre of the vesicle; the connection of the posterior end with the chorion becomes the allantoidean stalk, *Al*, while the smooth membranous connection between the front end and the villous chorion represents the commencing amnion, *Am*. The fold, constituted by the amnion and the chorion, grows backward over the embryo, as indicated by the dotted line, *Am'*, until it finally reaches the allantois stalk, and the amnion completely arches over the embryo. The growth of the amnion is quite rapid, so that early in fœtal life it comes by its own expansion to lie close against the inside of the chorion, with which it unites loosely. The amnion, however, can always be easily stripped off from the chorion, even at the very end of pregnancy. By the sixth week, the amnion stands well off from the embryo, but does not touch the chorion; by the fourth month it lies against the chorion. As it enlarges it also comes to enclose the stalks of the allantois and the yolk-sac, thus making the umbilical cord. For the detailed explanation of this process, see Umbilical Cord.

Histology of the Amnion.—The amnion consists of two layers: (1) The ectodermal epithelium; (2) the mesodermic connective tissue. The epithelium faces the amniotic cavity; it consists originally of low cylindrical cells, which apparently undergo during the later half of pregnancy a slow degeneration; indeed, in a surface view one can distinguish after the fifth month little more than the oval granular nuclei, and even these become each month more difficult to stain with the histologist's dyes. Over the surface one sees occasionally lighter round spaces between the nuclei; these spaces have been held to be true stomata by Winkler, but this interpretation is very doubtful. Viewed in vertical section, each cell is usually seen to end dome-like on the free surface. The epithelium thins out, according to Kölliker, forming a single layer of "Pflasterzellen," but I have not been able to observe this modification in my own preparations. Over the umbilical cord the epithelium becomes stratified, according to Köster and also Kölliker. The histological character of the mesodermic layer has never been satisfactorily elucidated. Some authors have described a larger number of tissues, muscles, nerves, etc., but there appears to be no satisfactory evidence of the existence of any such specialized tissues in the amnion. All that is certain is the presence of a gelatinous matrix of homogeneous appearance, in which lie a large number of cells of irregular shape and distribution. After staining with hæmatoxylon, nuclei of the most varied shape are brought out (Fig. 92), some round or oval and lightly colored, others more deeply stained and irregular in outline. Satisfactory observations in regard to the cell-bodies to which these nuclei belong are much needed. They should be first attempted upon the young amnion, as the cells become less distinct during the later stages. The amnion of the chick has contractile power, and is said to contain smooth muscle-fibres.

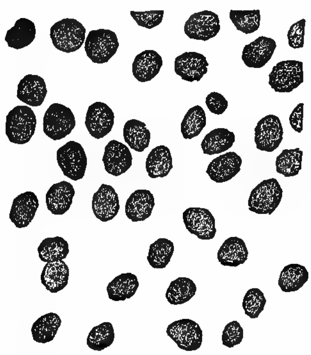

Fig. 91.—Nuclei of Epithelium of Amnion; Human Fœtus of about Six Months.

Concerning the evolution of the amnion nothing is known, nor do the speculations of Balfour ("Comparative Embryology," ii., 256) nor of Van Beneden and Julin ("Arch. de Biologie," v., 425) seem satisfactory, although the view of the latter is suggestive. They say: "Dans notre opinion, la cause déterminante de la formation de l'envellope amniotique réside dans la descente de l'embryon, déterminé elle même par le poids du corps. C'est par une accélération du développement que la cavité amniotique en est venu a se former quand l'embryon ne possède encore qu'un poids insignifiant." The chief objection to this theory is that it really gives no cause for the expansion of the somatopleure and chorion; there is no proof that a mere strain by weight can cause the cells of a membrane to proliferate, and since such proliferation is the immediate cause of the growth of the amnion, Van Beneden and Julin must assume for their theory that the strain of weight does cause proliferation; but this assumption lacks support.

Amniotic Fluid. The amniotic fluid, known also as the *Liquor amnii*, the *Fruchtwasser* of German writers, is a serous liquid, which entirely fills the cavity of the amnion, and bathes the embryo on all sides. We consider in this article, 1, its functions; 2, its quantity; 3, its composition; 4, its origin.

Functions.—The amniotic fluid obviously serves for the mechanical protection of the fœtus against sudden shocks, blows, or pressure; assists in the maintenance of a constant temperature, and affords the fœtus scope for its movements *in utero*. When deficient in quantity it may no longer prevent the pressure of the uterine walls from acting on the child, in which case deformities may result. It keeps the skin of the fœtus moist, and does the same for the genital passages of the mother during delivery; it is, however, not essential to the act of birth, as is shown by, 1, the delivery of the child in some cases

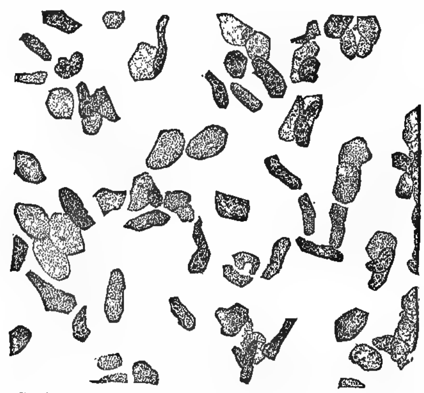

Fig. 92.—Surface View of the Mesodermic Layer of the Amnion; Fœtus of Six Months.

several hours after the outflow of the fluid, and, 2, the delivery of the child with the membranes intact.

The chief function of the fluid, however, is to serve as a water-supply to the embryo. It is probable that during the early stages of fœtal life, possibly during the greater part or even the whole period of intra-uterine existence, the embryo absorbs considerable quantities of fluid directly through the skin, but of this absorption we have no direct, certain proof. On the other hand, the swallowing of the *liquor amnii* by the fœtus *per oram* is well established, *first*, by direct observations of the bird's ovum; *second*, by the finding in the mammalian digestive tract of remnants of fœtal epidermis, hairs, and of the vernix caseosa, which can have reached their site only by being swallowed while floating in the amniotic fluid. That the embryo chick swallows the amniotic liquid was known to Harvey [1] (1651), and is said to have been observed by Haller; renewal and extension of these observations is much needed. As regards the swallowing by the mammalian fœtus there are many observations. Needham, Haller, Moriggia, and many others have found meconium in the stomach of fœtus; the presence of epidermal scales in the fœtal digestive tract appears to be constant; the presence of hairs and fat [2] (*Vernix caseosa*), or of fatty acids [3] derived from the fatty *vernix*, is very common in the meconium. The fact that the fœtus does swallow is established, and analogy with the bird suggests that it swallows constantly the liquor amnii, together with such detritus as may be suspended in it. As the fluid contains

only one to two per cent. solids, it can hardly serve as nourishment to the embryo. The above considerations, taken collectively, render the supposition plausible that the fœtus obtains much of its water from the amniotic fluid.

Quantity.—The amount of amniotic fluid at full term has been estimated by Fehling[4] and Levison.[5] The former burst the envelopes with the finger, or with a trocar, collected and measured the outflowing liquid; the afterflow was collected upon a tared linen lying on a waterproof sheet. The minimum obtained in any case was 265 c.c., the maximum 2,300 c.c. (certainly abnormal). The average amount at full term was 680 c.c.; for fœtus from the middle of the ninth to the middle of the tenth month, 423 c.c. Fehling observed 34 cases. Levison found the average of 22 cases, 821 gms.; Gassner[6] the average of 35 cases, 1,730 gms.; but as Gassner's results seem to deserve less confidence, we may safely conclude that at full term there is usually under one litre of amniotic fluid, while it must be remembered that the amount is extremely variable.

The amount during development gradually increases, but no exact proportion exists between the stage of development of the fœtus and the amount of fluid. Fehling attempted to show a relation between the length of the umbilical cord and the quantity, but Krukenberg[7] demonstrated from Fehling's own figures[4] that this conclusion was untenable.

Composition.—The liquor amnii has the character of a serous fluid. Levison[5] found its specific gravity to vary from 1.0005 to 1.0070, while, according to Prochownick,[8] it varies from 1.0069 to 1.0082. The latter found it to contain between 1.07 and 1.60 per cent. dry solids, giving 0.51 to 0.88 per cent. ash. With the increase of quantity there is no constant diminution of the percentage of solids. The following table, compiled from Vogt[9] and Scherer,[10] indicates the little that is known concerning the changes in composition during gestation:

	3 months.	4 months.	5 months.	6 months.	10 months.
Water	983.47	979.45	975.84	990.29	991.74
Albumen and Mucin	......	10.77	7.67	6.67	0.82
Extract	7.28	3.69	7.24	0 34	0.60
Salts	9.25	6.09	9.25	2.70	7.06

It is clear that there is a great diminution in the amount of albumen, especially toward the last month, and there is apparently a small diminution in the percentage of salts. The salts are such as are usually contained in serous fluids. In connection with the albumen, it may be remarked that the fluid contains no fibrin-forming material, as has been shown by Gusserow.[11] There is a small quantity of urea, but not more than is found in other serous fluids; hence, the presence of urea is no argument in favor of the view that the amniotic fluid is an excretion of the fœtal kidney. Early in gestation the amount is small, but it gradually increases, until the ninth month, 0.030 per cent., and tenth, 0.045 per cent. (Fehling). The figures of various authors differ greatly—sometimes no urea being found (cf. Preyer, "Specielle Physiologie des Embryos," p. 289). Finally, we have to note the presence of lymph-corpuscles, but whether they are always present, and, if so, in what numbers, is unknown; in a few cases they have been found in large numbers.

Origin.—It is a hypothesis of long standing that the *liquor amnii* is an excretion of the fœtus, and opinion has inclined to regard it as the product of the fœtal urinary apparatus. There is, however, no satisfactory argument of any kind in favor of this view, but, on the contrary, there are many forcible objections to it; while there is strong evidence to show that it is derived from the mother by direct transudation. It is to be considered, *firstly*, that the liquor has the composition of a serous fluid, transuded from the blood-vessels, and does not resemble urine; like other serous fluids it contains a small amount of urea, but this is no indication whatsoever of the urinary origin of the fluid; *secondly*, that the fœtal penis is completely closed during the greater part of embryonic life, because after the closure of the raphe on the stalk, the *glans* remains long imperforate, so that in the male, at least, the direct discharge of the urine into the amniotic cavity is impossible; unless, therefore, we are ready to attribute the formation of the fluid to different sources in the two sexes, we cannot assume the kidney to be the source of the fluid in either sex; *thirdly*, that the fluid is not excreted by the epidermal glands is proved by the very late development thereof, and the early and abundant formation of the fluid; *fourthly*, that the amniotic fluid appears very early, being certainly present in the third week, at which time the embryo is entirely without excretory or glandular organs of any kind, and all its tissues are still undifferentiated; *lastly*, that it seems improbable that the fœtus, which constantly requires water for its own use, should excrete a large quantity only to swallow it again.

That the *liquor* transudes directly from the uterine wall or from the chorion through the amnion into the amniotic cavity, is indicated, *first*, by the composition of the fluid; *second*, by experimental evidence that certain salts can pass directly from the mother into the fluid without passing through the fœtus, at least during the latter part of pregnancy. Zuntz[12] was the first to make such an experiment; he injected an aqueous solution of sulph-indigotate of sodium into the jugular vein of a pregnant rabbit; the liquor amnii showed a distinct blue color, while no trace of blue was found in any part of the fœtus. Wiener[13] repeated and extended this observation, and G. Krukenberg[7] made similar experiments, with like results, with iodide of potassium.

All the facts taken collectively, point, it seems to the writer, to the theory that the liquor amnii is a product of the osmotic function of the amnion; that, during the earliest period, the osmosis takes place from the fluid in the space between the amnion and chorion; that during a certain interval, namely, while the superficial capillaries of the chorion maintain an active circulation in that membrane (cf. Chorion), the fluid may come from the chorion, and, therefore, indirectly from the fœtus; and finally, that during at least the latter half of pregnancy, the transfusion occurs from the decidua through the chorion and amnion both. This theory, as far as known to the writer, is new; that the amnion itself produces the liquid it encloses, is highly probable, but the exact source of supply upon which the amnion draws is much more uncertain.

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13 Wiener: Ueber die Herkunft des Fruchtwassers, Arch. f. Gynæk., xvii., 24.

Charles Sedgwick Minot.

[NOTE.—Since the preceding article went to press an interesting paper, by Richard Haidlen, has been received, entitled, "Ein Beitrag zur Lehre vom Fruchtwasser," in *Arch. f. Gynækologie*, Bd. xxv., pp. 40 to 50. He gives a table of forty-three observations of the amount of the amniotic fluid determined according to Fehling's method, *vide supra*, and has recorded also for each case the sex, length, and weight of the child, the weight of the after

birth, the length of the umbilical cord, etc. Combining his observations with those of Fehling (thirty-four cases), he is still unable to detect any constant relation between the amount of the fluid and the weight of the child, the weight of the afterbirth, or the length of the umbilical cord. Haidlen's method of tabulation, however, hardly corresponds to the requirements of rigid statistics, and it is possible that a reworking of his figures will give different results. I find the average of his observations to be 714 c.c. of fluid; taking out two isolated extreme observations, one of 50 c.c., and one of 7,000 c.c. (hydramnios), the average of forty-one observations is only 577 c.c. Haidlen also failed to find any proportion between the percentage of solids and the amount of the fluid. Haidlen also repeated Krukenberg's experiment of giving women iodide of potassium in the early stages of labor, and also small repeated doses for several days before labor; in each case he found the salt in the amniotic fluid, and also in the first urine of the child. This experiment, therefore, does not show whether the diffusion takes place from the uterine wall or the fœtus into the amniotic cavity.]

AMPUTATION. Amputation (*amputare*, to cut away) is a term generally used to designate the removal by surgical operation of a portion or the whole of an extremity. In a wider application the word is still used with reference to separations of other prominent or projecting portions of the body, such as the mamma, penis, and cervix uteri. In this article amputations of the extremities alone will be considered. Older writers, and many of the present time in Germany and France, still further restrict the term amputation to the operative removal of a limb in its continuity, as in amputation through the forearm or thigh, while they designate as "disarticulations," "enucleations," the removal of a member in its contiguity (*i.e.*, through the joint). This distinction is properly ignored by English and American writers, since many operations present combinations of the two procedures. (Syme-Pirogoff.)

Historical Sketch.—The helplessness of surgeons of ancient times to cope with profuse hæmorrhage is generally accepted as the sole admissible explanation of the fact that, for nearly two thousand years, from the time of Hippocrates to that of Paré, amputations were practically limited to the removal by cutting through the dead tissues of gangrenous extremities. The only reference to amputations in the Hippocratic writings is as follows: "In case of fractures of the bones, when strangulation and blackening of the parts takes place, at first the separation of the dead and living parts quickly occurs, and the parts speedily drop off, as the bones have already given way; but when the blackening (mortification) takes place while the bones are entire, the fleshy parts in this can also quickly die, but the bones are slow in separating at the boundary of the blackening, and where the bones are laid bare. Those parts of the body which are below the boundaries of the blackening are to be removed at the joint as soon as they are fairly dead and have lost their sensibility, care being taken not to wound any living part; for if the part which is cut off give pain, and if it should prove to be not quite dead, there is great danger lest the patient swoon away from the pain, and such swoonings are often immediately fatal" ("Hippocrates," Sydenham, vol. ii., p. 639).

The anatomical labors of the Alexandrian school could not have been without influence on the status of surgery. This we see illustrated in the surgical writings of Celsus, who unquestionably was the first to suggest amputations in the living tissues above the line that separates them from the sphacelus. While he admits that patients frequently succumb during the operation from hæmorrhage, there can be no question but that Celsus was acquainted with the great usefulness of the ligature. In his chapter on wounds, he advises that,[1] "if these (plugging the wound, compression, and mild caustics) do not prevail against the hæmorrhage, the vessels which discharge the blood are to be taken hold of and tied in two places, about the wounded part, and cut through, that they may both unite together and nevertheless have their orifices closed."

It seems scarcely possible that the theory, if not the practice, of surgery could have developed to the position designated, unless a less difficult procedure for the ligation of a bleeding vessel in an open wound had been likewise perfected, particularly in view of the facts that Archigenes had introduced the tourniquet, that every writer of the Greek and Arabian schools makes repeated reference to the use of the ligature for the relief of hæmorrhage, and that torsion of bleeding vessels was advised under certain circumstances by Galen, Rhazes, and Paulus Ægineta. It is quite certain, therefore, that the proper management of hæmorrhage was not entirely lost sight of even in the darkest period of the history of medicine. Indeed, the indications for amputation seem to have been more elucidated for a time after the labors of Celsus. Thus Archigenes enumerates, among the circumstances which require amputation, "the presence of intractable disease, such as gangrene, necrosis, putrefaction, cancer, certain callous tumors, and sometimes wounds inflicted by weapons" (Syd. "Paul Ægin.," vol. ii., p. 410). Nevertheless, the advanced position occupied by this writer was soon receded from. For a thousand years from the time of the latter authority retrogression was the fate of amputations as of surgery in general. Where recourse to amputations was unavoidable, the most barbarous methods were resorted to. The Arabians operated with red-hot knives. Throughout the dark ages the actual cautery was applied to the bleeding stump, or this was covered with boiling oil, or molten pitch, or sulphur. More cruel than any other was the practice of Guy de Chauliac, who in the fourteenth century bound a cord with sufficient force around a limb to insure its removal by gangrene. While amputations were thus dreaded, until within the last three centuries, alike by surgeons and patients, it is certain that this operation was not called for so frequently as it is now. Lacerations as terrible as those produced by machinery and firearms, which for the most part force the amputating knife into the surgeon's hands, could hardly have been often encountered prior to the discovery of gunpowder and steam.

While Gersdorff, of Strassburg, probably had used the ligature in amputation wounds for some years, it remained for the genius of Paré to give to amputations a comparatively firm position among surgical operations. After nearly thirty years of experimentation and practical test of the ligature, he published results which should at once have revolutionized the surgical practice of the time. With the retraction of the skin and soft parts above the site of operation, to insure sufficient tissue to cover the divided bone, and the use of a constricting band, Paré had adopted all the preliminary means which are deemed necessary to-day by many for making a circular amputation. Grasping the open mouths of the arteries with curved forceps, he closed them with a double thread, and the wound with three or four sutures. Likewise was Paré the first who clearly taught the value of the ligature *en masse* in refractory hæmorrhages. "Inspired by God with this good work," it would seem that Paré should have speedily moulded the practice of his contemporaries. That this was not the case is evident from the great opposition encountered by him, and that it required nearly two centuries for the ligature to supplant the actual cautery as a hæmostatic measure. Although Fabricius Hildanus, in Germany, Dionys, in France, and Richard Wiseman, in England (last half of seventeenth century), make mention of the ligature, they in nowise recommend it. It is not remarkable, therefore, that in the seventeenth century, Botal did not hesitate to perform amputation by means of two hatchets, one placed immediately below the member and the other loaded with leads let fall upon it (Velpeau, "Operat. chir."), and that even as late as 1761 W. Sharp saw cause for complaint at the restricted practice of ligaturing bleeding vessels. Indeed, it is questionable whether the ligature of vessels in amputation wounds could even then have obtained a firm foothold without the assistance

given to it by the tourniquet. The origin of the latter is enshrouded in mystery. There can be no doubt that H. v. Gersdorff made use of constricting bands. It appears that the idea of provisional compression of the artery, as now practised, was introduced independently by two surgeons of different countries at about the same time. Morel, in France, and Young, in England, each devised a tourniquet for the arrest of the circulation. It remained, however, for the great J. L. Petit (1718) to elaborate the principles of arterial compression and to construct an instrument from which those now in use differ but little. Finally, with the introduction of digital compression and the use of the Esmarch bandage, the appliances for the control of hæmorrhage appear as perfect as human ingenuity can make them.

The most dangerous feature of an amputation being controlled, attention could be directed toward the securing of a more rapid cure and a useful stump. When in ancient and mediæval times an amputation terminated well, a year elapsed before the wound had healed, and a conical stump usually resulted. In 1678 a friend of Thomas Young expressed his great surprise that larger extremities could be removed in such a manner that the wound was firmly cicatrized by first intention in three weeks. The circular incision for amputations being the one most quickly accomplished and intuitively resorted to by the earlier operators, was the one generally adopted. Although Celsus clearly indicates the necessity of completely covering the ends of the bone with the soft parts, by dividing it upon a higher level, yet it was but rarely accomplished. This will not appear remarkable when we consider how the operation was described as late as the sixteenth century by Hans v. Gersdorff, the great barber-surgeon of Strasbourg: "And when you will cut him, order some one to draw the skin hard up, and then bind the skin with your bleeding-tape tight. Next tie a simple tape in front of the other tape in such a way that a space is left between the two tapes of one finger's breadth, so that you may cut with the razor between them. In this way the cut is quite reliable, goes easily, and makes a perfect stump. Now when you have done the cut, take a saw and separate the bone, and after that undo again the bleeding-tape and order your assistant to draw the skin over the bone and the flesh, and to hold it hard in front. You should have a bandage ready of two fingers' breadth; it should be moistened beforehand, so as to be wet through, then bind the thigh from above downward to the cut, that the flesh may protrude in front of the bone, and then bandage this too." [2] Amputation by a single circular incision down to the bone has since been revived by Louis and Brünninghausen in the beginning of our century, and has been advised by Esmarch recently in emaciated and exhausted subjects. [3]

Early in the last century J. L. Petit originated the first decided improvement upon the ancient method of practising the circular incision. With the first circular incision he divided the skin and subcutaneous cellular tissue alone, and after reflecting them divided the muscles upon a higher level by a second circular sweep of his concave knife. Cheselden and Sharp in England, and Heister in Germany, independently devised and became adherents of this improved operation, by which the end of the bone could be completely covered. To still further improve the stump Edward Alanson, after the customary circular incision through the skin, sought to give the wound a funnel-shape by applying the knife obliquely and dividing the muscles in the form of a hollow cone. Subsequent operators finding, however, that the wound thus made was not conical, but spiral, and that it entailed conditions unfavorable to primary union, this modification failed to get a permanent foothold among recognized operations. A better and simpler means to produce a conical wound was produced by Desault, who, after division of the skin, divided the superficial and deep muscles on different levels by two separate sweeps of the knife.

Meanwhile flap operations had been devised. Although, according to Velpeau and Lacauchie, Heliodorus had described amputation of superfluous fingers by the double flap operation, the knowledge of this method was entirely forgotten.* R. Lowdham, of Exeter, in 1679, introduced the flap operation for amputation of the leg by making a lateral flap on one side, a semicircular incision on the opposite side completing the operation. The incision was made from without, and included the skin and muscles of the calf of the leg. Although, as already indicated, Young (currus triumphalis) most highly lauded the results achieved by the new method, it was ignored until Peter A. Verduyn, of Amsterdam (1696), practised a similar amputation, transfixing the soft parts with a double-edged knife. Sabourin and Garengeot adopted the method by transfixion. Other modifications rapidly followed the first steps of the new method. H. Ravaton (1750), and Vermale (1767), surgeons of the Palatinate, recommended the formation of double flaps, while Charles Bell (1807), and the elder Langenbeck (Göttingen), again practically returned to the older operation of Lowdham. On the other hand, Sédillot, in 1841, and Teale, in 1858, greatly improved the double flap operation. Sédillot formed two musculo-cutaneous flaps, in which only a small part of the flesh was included, and divided the remaining soft parts by a circular incision. A number of operators advised that the flaps be of unequal size, lest the cicatrix become adherent to the divided end of the bone. Finally, Thomas Teale, of Leeds (1858), devised the antero-posterior rectangular musculo-cutaneous flaps. Scoutetten, of Metz, in 1827 combined into what is termed the oval method, a number of operations which had been previously employed by the older Langenbeck, Larrey, Guthrie, and others. According to Scoutetten, this method, which is best adapted to disarticulations, is supposed to possess the advantages of both flap and circular operations. While, on the continent, this operation has found a small band of followers, it has never met with general favor.

INDICATIONS.—Amputation has been termed the "last resource" and the "opprobrium" of the surgeon. Recourse to this radical measure signifies the surgeon's unbelief in his efforts to restore to usefulness an injured limb; it is his concession that, in the combat with disease, he has been conquered, or that his ability to rectify a congenital deformity is limited. To recognize the limits of his powers to save a part requires the keenest judgment of the surgeon, and it is remarkable how, in the history of amputations, this has swayed between the extremes of radicalism and conservatism. It is, of course, not remarkable that, prior to the introduction of the ligature, amputations were, for the most part, confined to the removal of parts which were all but removed by an accident itself, or were already the seat of gangrene. On the other hand, the multiplication of methods of amputation, during the last and the early part of this century, went hand in hand with the most reckless condemnation of limbs. The voices of Gervaise [4] and Boucher, [5] which were raised in defence of conservatism, were unheard, and even the remarkable reports of Bilguer were unable to stay the useless sacrifice of limbs. Bilguer, [6] the father of conservative surgery, and surgeon to Frederick the Great, could report, in 1763, 169 compound fractures successfully treated by conservative methods. Among these were 9 of the femur, 42 of the leg, 19 of the ankle, 9 of the head of the humerus, 16 of its shaft, 22 of the elbow, 9 of the forearm, 3 of the wrist, and 3 of the hand. The distinction which these statistics brought to Bilguer was materially dimmed by the fact that he published his successes alone, and that for a while he denied amputations a place among justifiable operations. The incredulity of surgeons in these results and extreme views was one of the causes which prevented them for many decades from restricting the indications for an amputation. Faulty methods of treating wounds and an insufficient appreciation of the dangers attending major amputations were likewise potent factors in so frequently forcing the amputating-knife into the hand of

* The importance of covering the end of the bone was patent to many—Barth, Maggi, among others. (Von K. Sprengel: Gesch. der Chir., vol. i., p. 408, Halle, 1805.)

the surgeon. The introduction of immovable dressings, the startling statistics of Malgaigne, published in 1842 and 1848, the favor with which excisions were received, and, above all, the advantage of antiseptic treatment in the widest sense, were the chief causes in finally determining the indications for amputations as they are now generally accepted.

In general terms, it is proper to resort to amputation when the sacrifice of a part, which is hopelessly diseased, is necessary to the preservation of life or the enjoyment of its various functions and duties. It is well to remember that "the vast majority of people would prefer living with three extremities to being buried with four." While in each individual case the danger and advantages of an operation are to be carefully balanced, conditions may arise which may make an operation imperative which but a few days before seemed uncalled for.

Contra-indications to amputation, either temporary or permanent, should also be clearly recognized. Among the former, particularly as to amputations for injury, should be considered extreme shock and exhaustion from excessive hæmorrhage. As permanent contra-indications, such conditions should be recognized as will preclude the possibility of attaining the object of all operative procedure, viz., the restoration of the patient to health. Such indications are, first, so extensive an involvement, by disease, of a limb and contiguous parts that amputation will not suffice for its complete removal, and, second, complications on the part of important internal organs from injury or disease, under which circumstances an amputation would not only be useless, but would probably curtail life.

While it is an axiom that amputation should be resorted to only under circumstances where no other means will avail, there is no little difficulty in determining the conditions that call for this extreme measure. They may be most readily investigated by considering them under the three general headings of injuries, non-traumatic lesions, and deformities.

(*a*) Injuries.—When, from accident of any kind, a limb is entirely severed from its connection, or the soft parts so mutilated that it is attached by skin alone, or by it and pulpified flesh, an amputation is absolutely indicated. Wounds from circular-saws, railroad accidents, extensive gun-shot lacerations, afford numerous instances in which the amputation consists in nothing more than trimming off the ragged edges of the wound, levelling the inequalities of the protruding fleshy masses, and placing the stump in the best condition for speedy repair. To this class of injuries belong those cases, caused by railroad trains, heavily loaded wagons, entanglement in machinery, etc., in which the soft parts are extensively torn from the bone, the muscles being pulpified, the blood-vessels and nerves lacerated. It is remarkable that in instances of this character the skin itself may remain unbroken, while all that it covers has been practically crushed. The shock attending the tearing off of a leg or an arm is usually so excessive that a formal operation with attendant loss of blood must be dispensed with.

On the other hand, it is a well-established fact that fingers, portions of the nose and ear which had been almost completely and even totally separated by an incised wound uncomplicated by contusion, have been permanently replaced by the careful use of sutures.

(*b*) Extensive burns and circumferential lacerations of only the skin and subcutaneous cellular layers may, in rare cases, require the sacrifice of a limb. When, from the depth of a burn, it becomes evident that the reparative process must be suppurative in character, and continue for many months, and when finally ended leave a disfigured and practically useless member, it is usually better at once to amputate than to expose the life of the sufferer to the dangers of septic infection, amyloid degeneration, or exhaustion. Extensive stripping of the integument from a member may likewise impel the surgeon to operative interference. A most interesting case of this character is recorded by M. Schede (Billroth und Pitha, vol. ii., Heft ii., 2 Abth., p. 19), in which an entire arm was caught in a cogwheel and stripped of its integument, the muscles of the arm and forearm being laid bare as in a careful dissection. Although amputation at the shoulder was successfully resorted to and the acromion removed, the integument was insufficient for the closure of the wound.

(*c*) The simultaneous injury of the main artery and vein of an extremity has usually been considered an indication for amputation, since it almost invariably results in its mortification if conservatism is practised. This has applied particularly to wounds of the femoral artery and vein. The advisability of an operation in all such cases must, however, be seriously questioned, since instances are multiplying in which, with neoplasms, several inches of the main vessels of the limb have been removed without resulting in its death. When the vein alone is slightly injured, it is far preferable to trust to a properly applied lateral ligature, or if completely divided, an attempt to save the limb should be made by ligation of the accompanying artery. Quite recently a case has been recorded by Pilcher in which an incised wound of both femoral artery and vein was successfully treated by double ligation of both vessels.[7] On the other hand, amputation may be required for the relief of traumatic aneurisms or those of spontaneous origin which have become diffused. Particularly may ablation of the thigh be preferable to other plans of treatment of aneurism of the popliteal and of the deep arteries of the leg in persons of advanced years. In cases of subclavian aneurism exarticulation at the shoulder has likewise been successfully performed as a modified distal ligation. Finally, secondary hæmorrhage after injuries from whatever cause, when other measures have failed, can be relieved alone by the sacrifice of the limb. Since after ligation in continuity of an artery the secondary hæmorrhage most frequently comes from the distal end of the vessel, it is apparent why amputation is often successfully practised.

(*d*) Compound fractures and dislocations are the conditions which most frequently call for amputation in all communities where manufacturing interests are largely developed and where railroads furnish employment to large numbers. Not very long ago, the presence of a compound comminuted fracture was deemed sufficient cause for an amputation, even if unattended by extensive laceration of the soft parts. In no field of surgery have greater triumphs been recorded than in the conservative treatment of these compound fractures. There can be no question but that to-day all surgeons of twenty years' experience save limbs which in their earlier experiences they would have doomed. For these results we are in the main indebted to the principles of antiseptic treatment, which, although first promulgated in 1865 in Glasgow by Mr. Lister, were first extensively practised on the continent, especially in Germany, by Bardeleben, Volkmann, and Nussbaum.

It is immaterial for our purpose which of the numerous antiseptic agents be preferred, or whether the open method of wound treatment with thorough drainage be employed. Such remarkable results have been achieved in the conservative treatment of compound fractures that ordinary cases may be said to present no indications for amputation. Nearly a year ago a lad of eighteen had his left arm caught in the belt of a machine-shop. When brought to the Good Samaritan Hospital, in Cincinnati, an hour after the accident, there was detected a double fracture of the humerus, one of which was compound, a simple dislocation backward of the elbow, a compound fracture in the middle third of the radius with two inches of fragment protruding, and a compound dislocation of the ulna at the wrist. An amputation was strenuously advised, but, fortunately, rejected by the parents. The boy, after confinement for nine months, recovered after two inches of the radius and six inches of the ulna were removed. The hand and forearm are almost useless, but infinitely preferable to the best artificial limb.

Statistics of the advantages of conservatism in the treatment of these accidents are rapidly accumulating. Thus Volkmann was enabled to report 75 compound fractures of the larger long bones without a single death, although in 8 cases he was compelled to resort to secondary

amputation. Sir Joseph Lister, with rigid adherence to the antiseptic method, lost 2 out of 97 cases. In the treatise of Billroth and Luecke[8] is a most exhaustive compilation of 254 cases which were treated by the Listerian method. Of 224 of these cases which were treated conservatively only 14 died. But it remained for our own countryman, Dr. Fred. S. Dennis, to record the most brilliant and, indeed, unique successes ever obtained in this field.[9] Of 144 cases of compound fracture treated in the New York Hospital, not one died from septic infection, and 100 cases were treated without a death from any cause. Extensive splintering of bone and laceration of soft parts can, therefore, no longer be considered an excuse for the sacrifice of the limb. If amputations still form a considerable percentage of the operations performed in large hospitals, it is because of the more extensive employment of heavy machinery, and the great extent of railway travel. Most of the primary amputations thus practised are indicated by the conditions above detailed. (Sub. *a*.)

(*e*) Closely allied to compound fractures in their relation to amputations are compound dislocations. Since the more general appreciation of the value of primary excision of joints, amputations for these injuries are now less frequently resorted to than formerly. Indeed, all formal operations for compound dislocations should be greatly restricted. Cooper[10] and Nelaton[11] already leaned toward conservatism. The latter advised reduction of the dislocation, closure of the external wound, and antiphlogistic measures. What has been accomplished in this way in recent years, and particularly by immobilization, could be demonstrated by a stately array of cases of compound dislocations of large joints in which the limb was saved, and often with perfect motion. Compound dislocations of shoulder, wrist, hand, and elbow, unless the damage of the soft parts is such as *per se* to call for amputation, should always be treated without operation, or by excisions. A compound dislocation of the elbow, with laceration of the brachial artery, was successfully treated without operation by McCarthy, and Davis[12] reports another such dislocation of the knee, in which all the functions of the joint were retained.

On the other hand, amputations for compound dislocations of the foot and ankle are more frequently indicated, since excision and conservative measures often leave the parts useless, if not positively a burden, and the dangers of primary amputations are at least no greater than those which attend milder methods of treatment of these cases.

(*f*) *Gun-shot Wounds.*—These are of sufficient frequence in civil practice to often call for amputation. Here, on account of suitable accommodations and facilities for proper treatment, conservative means may be adopted, where in the field a part must be sacrificed for the benefit of the whole. A recent writer thus enunciates the conditions which call for amputation:[13] "1. When there has been great destruction of soft and hard parts, as in a crush by large shot, or when the limb has been almost completely or altogether carried away. 2. When the fracture is associated with laceration of the main vessels or nerves of the part. 3. When acute, infective osteomyelitis has been developed. In the chronic form of this disease, when the entire length of the bone has become affected, it may or may not be necessary to amputate, according to the general condition of the patient, and the particular bone that is diseased. 4. When there is severe secondary hæmorrhage from an eroded vessel, or from a ruptured traumatic aneurism. 5. When traumatic gangrene has supervened."

(*g*) *Mortification.*—The presence of mortification, as a sequel of trauma or of the application of the extremes of heat and cold, offer an unmistakable indication for the ablation of a part as soon as the evidences of the limitation of the gangrene are made manifest. Nor is it always advisable to wait for this in the case of traumatic gangrene, which often extends with such rapidity that a few hours will rob the sufferer of his only chance. The mortification which follows the ligation of an artery, or upon an embolism, is a condition calling for operative interference. On the other hand, this is rarely permitted by the general condition of the patients in cases of senile gangrene.

(*h*) *Tetanus.*—Amputation may be said to be one of the most successful measures for the relief of traumatic tetanus. According to the latest experiences an equal proportion of good results follow this method and nerve-stretching. The latter should be given the preference in every case, when, in the event of failure, amputation should be resorted to as a *dernier ressort*.

NON-TRAUMATIC AFFECTIONS. — (*a*) *Inflammation.*—Severe and extensive inflammations of the skin, subcutaneous cellular layer, and intermuscular layer, as they are frequently encountered in phlegmonous erysipelas from injuries which in themselves are most trivial, and which from septic infection or protracted suppuration would lead to death, are conditions that may necessitate an amputation. While with free incisions, the permanent water-dressing, and irrigation, many limbs thus affected may be saved, amputation must always be resorted to in a certain small proportion of especially aggravated cases. The presence of septicæmia and pyæmia should not be deemed a contra-indication unless the want of vitality of the patient will preclude the possibility of surviving the shock resulting therefrom. Billroth, Volkmann, Fayrer, Weinlächner, Luecke, and numerous other surgeons cite cases in which amputation was successfully practised after a varying number of rigors had placed the presence of the gravest constitutional infection beyond doubt. By removing the primary seat of the septic changes, the general manifestations of pyæmia may frequently be caused to disappear.

(*b*) Inflammatory conditions of the bones and joints which cannot be relieved by less radical measures often make an amputation imperative. Acute spontaneous osteo-myelitis, when unrelieved by trephining, and when affecting only a single bone, must be considered a condition requiring this radical interference. Necrosis which involves the entire thickness of the shaft of the bone, when this is single on the part of an extremity (humerus, femur), and when repeated necrotomies have been unavailing, occasionally requires the sacrifice of a limb. In extensive caries of the articular ends of the long bones, or of the carpus and tarsus, when from the depraved condition of the patient excision is unfeasible, amputation is compulsory. The improved methods of dealing with suppurative and destructive affections of joints by immobilization, and, if need be, by resection, have happily reduced the number of cases calling for amputation from these causes to a minimum.

(*c*) Extensive circumferential ulcerations of the leg, which sap the strength of patients through hæmorrhage or profuse suppuration, or which unfit the patient for the vocations of life, not unfrequently render amputation advisable. This also applies to cases of true and spurious elephantiasis, in which milder measures have proven of no avail.

(*d*) Tumors of benign and malignant character, when from their size they destroy the usefulness of a limb or endanger life, are well-recognized indications for amputation. The neoplasms most frequently demanding the latter are carcinomatous degenerations of chronic ulcers or epitheliomas developing around a sequestrum, or an osteo-sarcoma of the articular ends of the long bones. Under all these conditions amputation offers a better chance for permanent recovery than excision. The rule which applies to the management of neoplasms generally, that an operation must be refrained from unless all of the diseased tissue can be removed, is particularly to be remembered before an amputation is determined upon for the relief of a tumor of an extremity. The bearing of amputation to certain traumatic affections of the blood-vessels and special spontaneous aneurisms has already been referred to. Congenital telangiectases likewise exact amputation when rapidity of growth endangers life or when other plans of treatment have been unsuccessful.

DEFORMITIES.—(*a*) Supernumerary fingers and toes are proper cases for removal, and the operation may be safely practised six months after birth. This early re-

moval assures a better form of hand or foot and a diminutive scar. Cases of club-foot which have been altogether neglected or badly managed, and which, from extensive ulceration or inflamed bursæ, entail great suffering upon patients, not infrequently can be relieved by amputation only. But in early life no case of talipes is of sufficient severity to warrant the removal of the foot.

(*b*) Cicatricial contractions of the joints, associated with great wasting of the muscles, from extensive burns; great deformity and uselessness of a limb from neglected dislocation (foot or ankle), may call for an amputation. For these and similar cases, amputations of expediency may occasionally be required, but the surgeon should carefully weigh all factors in the case before subjecting his patient to the risks of an operation for the relief of a condition which in itself is only a burden and not a source of danger.

Time for Amputation.—When, in consequence of an injury, an amputation is indicated, the proper time for performing it must be considered. While the patient is still suffering from shock, collapse, or even exhaustion from excessive hæmorrhage, it would be sealing his fate to resort to an operation. At least moderate reaction must invariably be awaited, irrespective of its early or late appearance. When reaction has once been established, with the aid of restoratives, the most appropriate period for an amputation has arrived, since, for a period varying from twelve to seventy-two hours, the injured part remains in apparently the same condition that it was in immediately after the accident. After this interval, there may be expected to supervene those local and systemic manifestations which belong to severe inflammatory changes in the injured part. All amputations practised prior to the advent of these changes are designated *primary amputations.* Since the time when these changes supervene varies from one to three or four days, according to a multitude of circumstances, foremost of which are the constitution of the patient and the character of the wound, no absolute limit can be fixed to the time when an amputation should no longer be classed among the primary amputations. With very few exceptions, surgeons of the present day recognize the necessity of immediate amputation in every instance where conservatism cannot be practised. The diversity of opinion which has prevailed on this subject has been great. Among the advocates of primary amputation may be enumerated Du Chesne, Wiseman, Pott, Percy, J. Bell, Larrey, and Guthrie; among its opponents, Faure, Hunter, and, within the last quarter of a century, J. Neudörffer, Paul, and Gross. The extensive experiences of Guthrie and Larrey have finally convinced surgeons of the advantages of early, as compared with late, amputations. Of 291 primary amputations, 107 recovered, 24 died, and 160 remained under observation. Of 551 secondary operations, 170 recovered, 265 died, while 116 remained under treatment (Guthrie). The accumulated experiences of the Crimean and Franco-Prussian wars, and the vast statistics of our civil war, indorse the prevailing practice of resorting to early amputations. In the statistics of Otis, there were in 3,259 primary amputations of arm, 602 deaths, 18.4 per cent. mortality; in 902 intermediary amputations of arm, 302 deaths, 33.4 per cent. mortality; in 411 secondary amputations of arm, 114 deaths, 27.7 per cent. mortality; in 1,914 primary amputations of lower third thigh, 927 deaths, 48.7 per cent. mortality; in 676 intermediary amputations of lower third thigh, 459 deaths, 67.9 per cent. mortality; in 207 secondary amputations of lower third thigh, 100 deaths, 48.3 per cent. mortality. The obvious reasons for the better results which follow early operations are that they are made at a time when the constitution has not yet been exhausted by protracted suppuration and high temperatures, and that they leave wounds which can be kept free from septic infection.

The second date at which an amputation might be forced upon the surgeon is that during which the severest local and general signs of inflammation present themselves. The damaged limb has become red, œdematous, and painful. From the wound there issues a sanious, malodorous fluid, and a more or less extensive sloughing of the tissues adjacent to the wound ensues. Associated with these local conditions are an acceleration of pulse, elevation of the temperature, often to a dangerous degree; headache, dry tongue, scanty urine, and muttering delirium. Unless the patient succumbs to the paralyzing influences of excessive temperatures, his condition becomes gradually ameliorated in from five to fifteen days. As the discharge of scanty serum is followed by a free secretion of pus, the gangrenous parts are exfoliated, and the swelling largely subsides; the fever and acceleration of pulse are reduced; the tongue regains its normal moisture and color, and a comparative degree of comfort is enjoyed. Amputations practised during this stormy period of the clinical history of an accident have, after the designations of Boucher and Alcock, been called *intermediary.* Since they are made at a time when the damaged part and the system at large are in the very worst condition for operations, it is not remarkable that such amputations offer the worst prospects for recovery. Although the mortality following such amputations must therefore be very much greater than that following primary or late amputations, cases will arise in which the very gravity of the local and general phenomena, such as recurrent hæmorrhage, impending gangrene or septicæmia, will necessitate the speedy removal of the limb, as the last hope of deliverance.

With the subsidence of the grave constitutional symptoms and the advent of profuse suppuration, begins that period when if amputations are performed, they are termed *secondary.* It has already been seen that the prospects of recovery after amputations in this period are less promising than after those of an earlier period. An equally strong objection to waiting for this period is that more of a limb must generally be sacrificed than by an early operation. Thus Guthrie observes that, "When an amputation is delayed from any cause to the secondary period, a joint is most frequently lost; for instance, if a leg be shattered four inches below the knee, it can frequently be taken off on the field of battle and the joint saved. Three or four weeks after, the joint will in all probability be so much concerned in the disease that the operation must be performed in the thigh; the same in regard to the forearm and hand, and the upper part of the arm with the shoulder." Notwithstanding the drawbacks attending secondary amputations, certain circumstances frequently make them imperative. Continued fever, impending exhaustion from excessive and protracted suppuration and evident uselessness of the limb, even if saved, may force the knife into the hand of the surgeon, after much valuable time has been lost through an error of judgment on his part, or a procrastination on the part of friends.

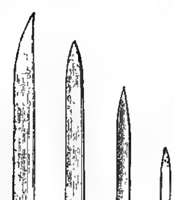

Fig. 93.

Preparations.—Before beginning an amputation it is essential to make such preparations for it as are required for every major operation. If possible, this should be made in the early part of the day, in order that if there be much hæmorrhage subsequent to the operation its source can be looked for without artificial illumination. It can be most satisfactorily performed on any operating table, or in the absence of this on two kitchen tables placed end to end. The instruments necessary for major amputations are: 1. An Esmarch elastic bandage and strap for the production of anæmia of the part to be removed. 2. A suitable tourniquet. 3. Amputating knives of various lengths and widths, with at least one double-edged blade (Fig. 93) (catling). 4. One large and one metacarpal amputating saw. 5. From six to twelve hæmostatic forceps. 6. A bone-cutting forceps, and a lion-jawed forceps. 7.

Carbolized animal and silk ligatures, drainage-tubes, needles, and an abundance of hot water.

The preparations which are to be made for the after-treatment, although they are necessarily a preliminary to the operation itself, will vary according to the plan to be adopted, and will be considered at some length hereafter.

While a finger or toe can be removed by a surgeon with only such aid as a layman can give, at least three assistants are required for every larger amputation. The duties of these should be first clearly defined by the operator, lest valuable time be lost during the operation. The undivided attention of one must be given to inducing and maintaining anæsthesia. The second is to support the part to be removed, after which he can be entrusted with the ligation of the vessels. The duty of the third should be confined to controlling the circulation of the limb above the seat of operation and eventually to retract the flaps. Where there is a fourth assistant, it should be his duty to hand the instruments to the operator as he may require them. This assistant is dispensable, since when the instruments are placed on a table near the operator, the latter can help himself quite as expeditiously as when assisted to them. These details arranged, the patient is anæsthetized and brought into such a position that the limb to be removed is everywhere accessible. The part to be removed must now be carefully wrapped in towels, the entire limb thoroughly cleansed with soap and brush and the hair removed from the part where the incision is to be made. The surgeon is then ready to take the final and most important preliminary measure for the amputation, that by which he intends to control the circulation of the limb and reduce the loss of blood to a minimum.

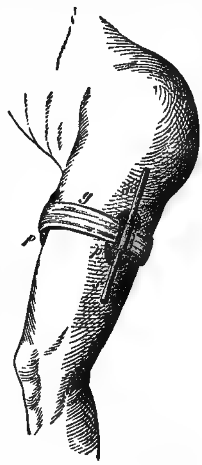

Fig. 94.—Morel's Tourniquet.

There are various methods by which the circulation may be more or less controlled during an amputation, and they are of sufficient importance to justify a detailed consideration. To prevent hæmorrhage the surgeon can choose between tourniquets, digital compression, and the Esmarch elastic bandage, or combine the latter with one of the other two. From the time of Morel the ingenuity of surgeons has been taxed to devise an instrument which will safely compress the main artery of a limb above the point where an amputation is to be practised. Of the many instruments introduced, only a few have been able to gain general recognition. The oldest of these is the Spanish windlass or garrôt of Morel, which consists of nothing more than a wide band (*g*) of an unyielding material (muslin or linen), firmly drawn around the limb and tied. Over the main artery and at a point diametrically opposite, there are inserted underneath it compresses of linen, a piece of thick leather, or a piece of paste-board (*p*). At a point opposite the artery a firm rod (*s s*) is introduced underneath the encircling band and turned in such a manner as to shorten the latter, and thus the compression of the main artery is effected (Fig. 94). Owing to the simplicity of its construction the garrôt of Morel stands without a peer in cases of emergency in civil as well as military practice. It has, however, one great detraction which renders its use a matter of necessity rather than of choice. Notwithstanding the use of the pads of linen or leather already referred to, veins, arteries, and soft parts are compressed to an almost uniform degree; hence extensive venous hæmorrhage and insufficient retraction of the muscles follow. A great improvement on the windlass is the tourniquet of Petit which is now so generally in use. It consists of two metal plates, the distance between which can be regulated by a screw, and which are connected by a strong linen band supplied with a buckle, by which the limb is encircled (Fig. 95). To apply it properly, the limb should be surrounded by a few turns of a roller, while the body of the bandage (*p*) is placed over the artery (*a*). Over this bandage the lower metallic plate is then placed, the band and buckle are fastened, when, by turning the screw, compression of the main vessel can be regulated at pleasure. The objection has been raised to the tourniquet of Petit that it compresses not only the artery, but also its accompanying vein, and thus induces venous stasis, and enhances the dangers of thrombosis. While this is doubtless true, it is an insurmountable defect common to all tourniquets; and based more on theoretical than on clinical data. When properly applied the tourniquet of Petit is not apt to slip or yield, and its safety is such that in case of emergency the management of the screw might be entrusted even to a layman. In order to limit the compression to the main vessel alone, complete or incomplete metallic rings have been devised which, while they surround the limb more or less completely, make compression at only two points, *i.e.*, over the artery and at a point diametrically opposite. The best known tourniquets constructed on this principle are the horseshoe tourniquet of Signorini and Dupuytren, the arterial compressor of the late Professor Gross, and the abdominal tourniquet of Pancoast and Lister (Fig. 96). While with these the compression can be limited to the main vessels of the limb, and the circumferential constriction of the latter is thus avoided, they are more liable to slip than the tourniquet of Petit, and are far less reliable than digital compression. For certain amputations, however (of the hip and shoulder), the instrument of Petit is inapplicable; it is then that one or other of the horseshoe tourniquets or digital compression will be found indispensable.

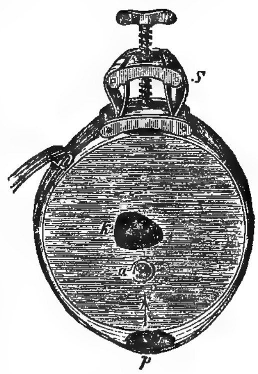

Fig. 95.—Petit's Tourniquet.

Digital compression, when made by trustworthy hands, is admirably suited to control temporarily the circulation. If compression of the artery alone is anatomically possible, it can be best accomplished by the finger. To be practicable, the vessel must be contiguous to a bone against which it can be pressed, as the femoral upon the os innominatum, the brachial upon the humerus, the subclavian against the first rib, or the abdominal aorta against the vertebræ. Since only a few minutes are required for the amputation of a limb, and the ligation of the larger arteries, the endurance of the assistant entrusted with the duty is not severely tasked. In digital compression, associated with the use of the elastic bandage, we have a combination with which the circulation of a limb can be completely controlled, and by which parts, the compression of which would be useless or even harmful, are protected. Notwithstanding the advantages of this method, the surgeon should never resort to it unless he can absolutely rely upon the ability and skill of his assistant.

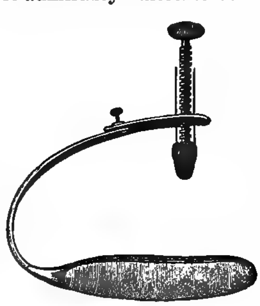

Fig. 96.—Horseshoe Tourniquet.

Elastic Compression.—Notwithstanding the precautions against hæmorrhage after amputations, these were invariably associated with very great loss of blood until twenty years ago. The blood thus lost was venous in character, and came from the veins of the amputated member. Through the practices of Grandesso Silvestri,[14] an Italian surgeon, and particularly of Esmarch,[15] of Kiel, the blood contained in the part to be removed is saved, and that this is not an inconsiderable quantity has been demonstrated by experiment.[16] The apparatus of Esmarch consists of

an elastic bandage and an elastic tube or flat band with chain or clasp attachments. Commencing at the fingers or toes, the bandage is applied by spiral turns until the limb is covered to a line at least four inches above the point where the bone is to be divided. Above the last turn of the bandage, the elastic band or tube is rather firmly and repeatedly wound around the limb, and secured by clasp or hook and chain (Fig. 97). When the bandage is then removed, a condition of ischæmia is observed in the limb, which will permit its amputation without a more than appreciable loss of blood during the operation proper. When the elastic strap is removed, the integument of the stump rapidly assumes a bright-red color, and in the wound there appears free, persistent, and often embarrassing, capillary oozing. It is generally accepted now that the source of this hæmorrhage is from the dilated capillaries, the walls of which have been paralyzed in consequence of the pressure exerted by the strap on the vaso-motor nerves. When in from twenty to thirty minutes the vessel-walls regain their tonicity, the hæmorrhage ceases. To check this capillary oozing, a number of remedies have been suggested. That of Riedinger,[17] to apply the faradic current, while very serviceable, is not always practicable. Esmarch relies upon closure of the wound and elevation of the stump before the strap is entirely removed. Hot water (150° to 180° F.), applied with sponges, often acts admirably in these cases. Since compression of the vaso-motor nerves, caused by the bandage, is the cause of this parenchymatous hæmorrhage, this can best be obviated by completely substituting digital compression for the elastic strap, or, if the latter be used, by preventing, the ingress of blood by the use of a tourniquet until the vessels have regained their natural tone. The latter plan, as practised by Ashhurst,[18] is "to place a tourniquet in position, but not screwed down over the main artery of the limb, and then to apply the Esmarch tube a few inches above the point at which it is intended to amputate. As soon as the principal vessels have been secured, the tourniquet plate is screwed down, and the tube removed. No bleeding follows, and by the time that the remaining arteries requiring ligatures have been tied, the vessels will have regained their tone, and the tourniquet can be removed without any risk of bleeding following." In amputations near the trunk, the elastic strap or tube should not be used in the ordinary manner. (See Special Amputations.) In an amputation of the shoulder, and another of the hip, I have seen it loosen or slip over the stump immediately after the disarticulation was effected, and in both instances the hæmorrhage was most alarming. In amputation at the shoulder, when, by the use of the bandage, the blood in the extremity has been returned to the economy, it is better to rely upon compression of the main artery against the first rib with the finger or a padded key. In amputations of the hip, the main artery can be compressed against the pubic bone, or even the circulation in the aorta can be controlled by one of the many compressors already referred to.

FIG. 97.—Esmarch's apparatus.

METHODS OF AMPUTATION.—Every amputation consists of three steps: 1. Division of the soft parts; 2, division of the bone, or disarticulation; 3, ligation of the vessels and closure of the wound.

According to the method adopted for the division of the soft parts, amputations are classified as circular or flap operations, and in the choice of the method the surgeon must be guided by the condition of the soft parts about the bone, the ease with which the joint can be opened in a disarticulation, the probable position of the cicatrix and form of the stump, and, above all, the desire to save as much of the limb as possible. Of the circular and flap operations all methods of amputation may be said to be but modifications. By the circular method it is attempted to give to the stump the form of an inverted cone or funnel, the apex of which is occupied by the divided end of the bone, the base or margin of which is represented by the cutaneous margin of the wound. In the flap operation the soft parts are so divided as to make one or more flaps, the bases of which are on a level with the divided bone, and the free margins of which are so adapted to each other as to completely cover the bone and admit of the ready closure of the wound. Whatever plan of operation is adopted, the surgeon should stand in such a position that he grasps the stump with his left hand, and that the amputated part therefore falls toward his right side.

Circular Method.—All modifications of the circular method have a similar incision through the skin and subcutaneous cellular layer, which is made around the entire circumference of the limb and at a right angle to its axis. According to the depth to which the incision is carried, the method is subdivided into that by single incision and that by double incision.

Single incision: This, as already remarked (see History), is the oldest method of amputation, and is generally known as the Celsian operation. After retraction of the soft parts a long amputating knife is swept around the limb, and all of the soft parts are divided down to the bone. This is then divided on a slightly higher level by the retraction of the soft parts. While this operation yields the smallest wound, and is the most rapid in its execution, its manifest disadvantage is in the insufficient covering which it affords for the bone. It is admissible only in greatly emaciated subjects. Brünninghausen,[19] in the beginning of the century, reintroduced this method, but, after the amputation of the limb was completed, made a second section of the bone several inches above the point at which it was first divided.

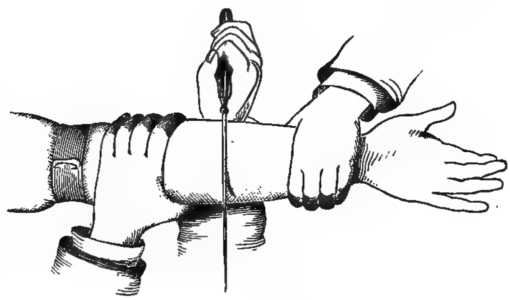

FIG. 98.

Double incision: This operation, of which those of Petit, Cheselden, B. Bell, Desault, and Alanson, are but unimportant modifications, has received its name from the fact that the skin, underlying fascia, and muscles are divided upon different levels, and, therefore, by at least two circular incisions. It is made as follows: The surgeon, firmly holding the limb with the left hand, carries his right hand, in which he firmly holds a large amputating-knife, underneath and around the limb until the heel of the cutting edge is over the uppermost part of the line of the proposed incision. Giving the knife this position forces the operator into a more or less stooping posture, from which he raises himself as the incision is completed. This is commenced with the heel of the knife, which, by a single sweep, is carried around the entire circumference of the limb, severing the skin and adipose layer down to the deep fascia (Fig. 98). Two incisions, the ends of which meet, will answer as well as the division by a single sweep of the knife. As soon as the

integument is divided the wound gapes. The upper margin is raised by the thumb and finger of the left hand, and gradually detached from the fascia by repeated long incisions carried perpendicularly to the axis of the limb. This operation of detachment is continued until the skin and adipose layer can be reflected like a cuff, the length of which should be equal to half the diameter of the limb

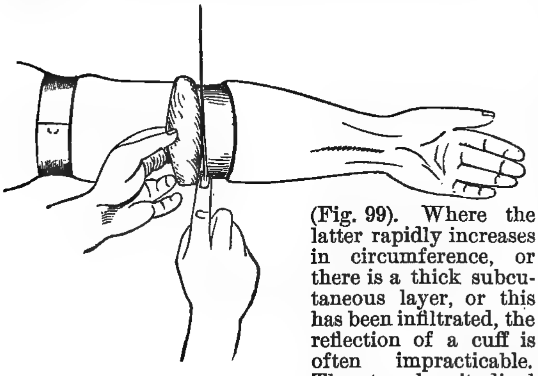

FIG. 99.

(Fig. 99). Where the latter rapidly increases in circumference, or there is a thick subcutaneous layer, or this has been infiltrated, the reflection of a cuff is often impracticable. Then two longitudinal incisions, diametrically opposite each other, will materially facilitate this part of the operation, although by this means the amputation is in a manner converted into a flap operation. The integument having been reflected to the required extent, the muscles are next divided close to the line of reflection by one steady circular sweep of the knife, which should cut through everything down to the bone (Fig. 100). Where there is

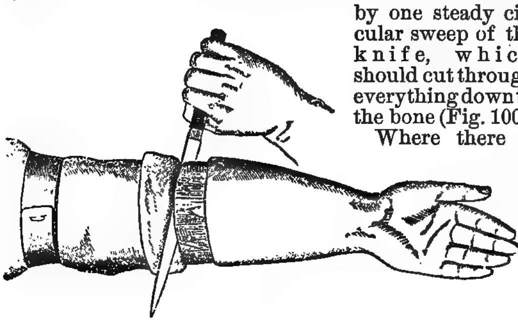

FIG. 100.

but one bone to be divided, the surgeon is now prepared to use the saw. Where there are two bones, the interosseous tissues remain to be divided. Whereas this can be accomplished with an ordinary amputating-knife, it is safer to use a double-edged instrument (catling) for this purpose. By using it in the manner indicated in Fig. 101, there is no danger of cutting the blood-vessels twice, and thus one danger of troublesome hæmorrhage is avoided. To protect the soft parts from injury by the saw, they must be well retracted by the hands of an assistant, or by the use of a band of muslin (retractor) divided into two or three slips, according to the absence or presence of an interosseous space (Fig. 103).

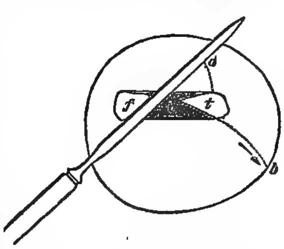

FIG. 101.

When it is deemed advisable to save sufficient periosteum to cover the divided end of the bone, this can now be readily effected with the back of the knife or the handle of the scalpel. The utility of this procedure must certainly be questioned, since in a number of instances it has interfered with the ready drainage of the medullary cavity, and has thus been the indirect cause of a fatal issue.[20]

The movements of the saw can be greatly facilitated by guiding them with the nail of the left thumb (Fig. 103). The to-and-fro movements of the saw should be slow, lest the heat developed by its too rapid use endanger the vitality of the bone. Where there are two bones of the same diameter (forearm), they should be divided simultaneously. In the leg, the tibia is to be almost entirely divided before the section of the fibula is commenced. Unless this precaution is adopted, splintering of the bone is not easily avoided. For the same reason, the assistant in charge of the part to be amputated should hold it horizontally, allowing it neither to drag by its weight nor to be raised in a manner to interfere with the movements of the saw. Should splintering of the bone nevertheless occur, the splinters and sharp margin of the latter must be removed with the cutting bone-forceps.

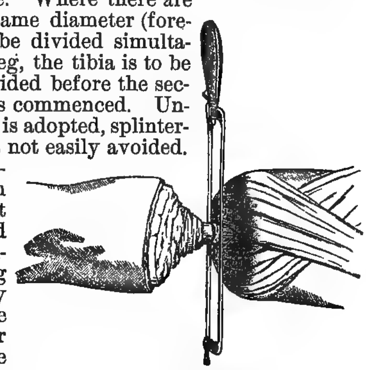

FIG. 102.

Oval Method.—Holding an intermediate position between the circular and flap operations is the oval method, which, although practised by the older Langenbeck and

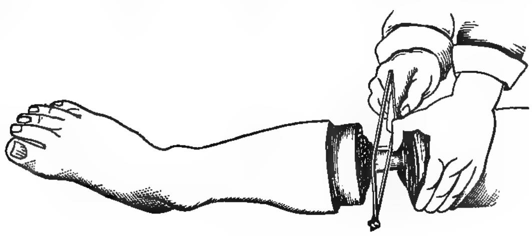

FIG. 103.

others, was first generalized by Scoutetten (1827). The essential feature of this amputation in the continuity of the limb is, that the incision, instead of being made perpendicular to its long axis, is carried at an angle of forty-five degrees, and in such a way that the soft parts in front of the bone are divided upon a higher level than those on its posterior aspect. At the same time the upper portion of the wound is converted into an acute angle, whereas its lower portion is given an oval outline. The upper extremity of the wound is placed at the point where the bone is to be divided. The operation is commenced by two incisions, in the form of an inverted **V**, the lower ends of which are united by a transverse cut on the posterior surface of the limb (Blasius). Here, as in the circular amputation, by a single incision all the

FIG. 104.

soft parts are divided at once on each side of the bone and then those on its posterior aspect. This operation has been generally discarded for amputations in the continuity, although for disarticulations at certain joints it presents advantages which are worthy of consideration (see Fig. 104).

Flap Method.—As already indicated, this consists in the formation of one or more flaps, comprising integument and muscular tissue, or integument alone, designed in a manner to completely cover the divided extremity of the bone or its exposed articular surface. According to the anatomical components of the flaps, they can therefore be called tegumentary and musculo-tegumentary.

FIG. 105.

Tegumentary Flaps.—This operation is generally practised by making two semilunar incisions, the ends of which meet on opposite sides of the part, down to the deep fascia, and dissecting up the skin and subcutaneous cellular layer to an extent sufficient to cover the stump (Fig. 105). When it is practicable, the flap should be taken from the anterior and posterior aspects of the limb in the forearm, thigh, and leg, and they should not be of equal lengths, the anterior flap usually being made longer to fall like a curtain over the divided end of the bone, where it comes in contact with the posterior (shorter) flap. In recent years the tegumentary method, with only one cutaneous flap, made from the anterior surface of the limb, has been most highly advocated (Carden, Bruns). When, from choice or necessity, a single tegumentary flap is to be made, the incision should be commenced on a level with the point where the division of the bone is contemplated, and carried for a varying distance down one aspect of the limb, parallel to its axis, and then by a wide curve on the opposite side to a point on a level with its commencement (see Fig. 106). In this manner the base of the cutaneous flap extends over half the circumference of the limb, while its length should be greater than its antero-posterior diameter at the level of the amputation. After separation of this flap from the deep fascia (it may be made to include this) it is reflected and the ends of the incision united by a posterior incision carried perpendicularly to the axis of the limb as in the circular operation (Fig. 106).

FIG. 106.

Whether one or more cutaneous flaps be made, the division of the remaining soft parts is practised by a single sweep of the knife, carried perpendicularly around the limb at the base of the flap, as in the circular operation. Owing to this division of the muscles, amputations by the tegumentary flap method are not infrequently called "modified circular operations."

Musculo-tegumentary Flaps.—Here, as in the tegumentary method, one or more flaps may be made, to cover the stump. They may be formed by transfixion of the limb and cutting from within outward, or by cutting from without inward, or by making one flap by the former and the other by the latter mentioned method. Where there is but a single bone (thigh, arm), it is customary to make at least one flap by transfixion. The integument being well retracted, and the soft parts raised from the bone with the left hand, a sharp-pointed and large amputating-knife is passed through the limb from side to side, the knife being made to graze the surface of the bone (Fig. 107). By a sawing movement the instrument is gradually carried downward and forward, and then obliquely outward, thus forming a wide flap with convex margin. The danger of making a flap too narrow is best avoided by not cutting outward too soon. The knife is then entered at the angle of the wound on one side, passed around the bone on the side where the soft parts are still adherent, and out at the opposite end of the wound. The second flap is then made by cutting outward as before. The flaps being now retracted, the knife is rapidly carried around the bone, as high as possible, to divide the muscular tissue still adhering to it. The application of the saw then follows. In order to make sufficient allowance for shrinkage the flaps should have a length at least equal to three-fourths the diameter of the limb. Redundance of the flap is always preferable to insufficiency, since the excess of muscular tissue can easily be removed with a few strokes of the knife. In flap operations, owing to unequal retraction of the soft parts, tendons and nerves are particularly apt to protrude above the surface of the wound, thus giving it an irregular appearance, and interfering with its ready union. After ligation of the blood-vessels, these protruding masses are to be carefully removed with the scissors. The protrusion of the muscular tissue of the flap and the irregularity of the latter can be totally avoided by cutting from without inward. This plan, generally known as that of Langenbeck (Fig. 108), insures perfect symmetry of the flaps, and permits the ligation of the vessels as they are exposed or divided. It is also practicable to cut through the skin and subcutaneous tissue from without inward, and complete the operation by transfixion. Although already practised by Dupuytren,[21] this plan has been recently advocated by Agnew ("System of Surgery," vol. ii., p. 305).

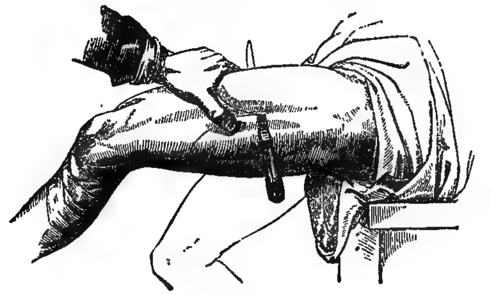

FIG. 107.

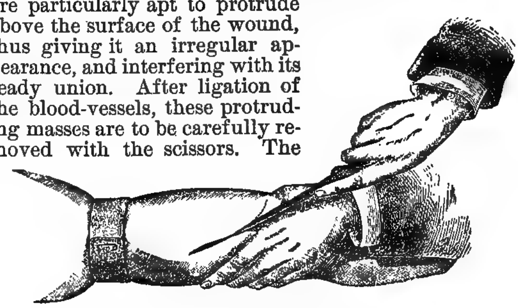

FIG. 108.

Rectangular Flap.—In 1855 Mr. Teale, of Leeds,

practised the formation of one long and one short rectangular flap, each of which comprised one-half the circumference of the limb and all the tissues down to the bone. The operation is made as follows: A rectangular anterior flap (posterior in the forearm), equal in length and breadth to half the circumference of the limb at the base of the flap, is marked out by one transverse and two parallel longitudinal incisions, the latter involving only the skin and superficial fascia, the former being carried down to the bone. The longitudinal incisions should be so placed that the posterior obtains one-fourth the length of the anterior flap. The two flaps are then turned up from the bone, from below upward, and the saw applied. To insure equal width of the flaps at their bases and their extremities it is best to map out the flaps by actual measurement before the incisions are made. In closing the wound the long flap is doubled upon itself so that the square ends of the two flaps are brought into apposition, where they are retained by a number of sutures (Fig. 109).

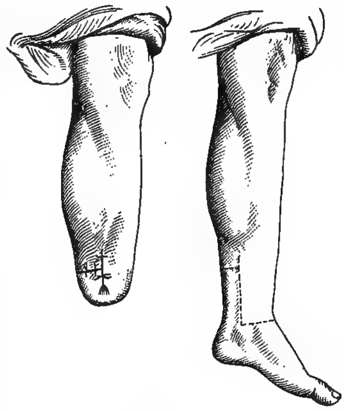

FIG. 109.

COMPARISON OF METHODS.—The surgeon who would obtain the best results after amputations should be familiar with all the different methods without becoming too partial to any, since the condition of the part to be amputated, the thickness and vitality of the subcutaneous cellular tissue, the position of the wound, and many other circumstances should guide him in the selection of a method rather than individual preference. To save as much of a limb as possible must be the first aim of the operator, and this can only be accomplished by resorting to various methods according to the exigencies of individual cases. If one method of operating deserves a preference, it is that by tegumentary flaps with circular division of the remaining soft parts. By this method the position of the angles of the wound for favorable drainage and that of the cicatrix can be readily determined, and when two oval cutaneous flaps are made no anxiety for their vitality need ordinarily be entertained. When the subcutaneous cellular layer is very thin, there is a manifest advantage in dissecting up with the integument some of the superficial muscular fibres. The marked advantage of the tegumentary flap over the circular method lies in the fact that by it, when the disease extends higher on one side of the limb than on the other, it often enables us to amputate several inches lower than we could by the circular method. While during the early part of this century the musculo-cutaneous method, by transfixion, was very extensively practised, on account of the rapidity with which it could be executed and the muscularity of the stump which it left, it is gradually being discarded for two reasons chiefly. In the first place, the general use of anæsthetics has removed the necessity for unusual haste, and in the second place, the muscular tissue left in the stump generally undergoes atrophic changes from disuse during the first year. A most decided disadvantage of the musculo-tegumentary flaps exists in the oblique division of the blood-vessels, on account of which they are often difficult to find and to ligate. It is for this reason that secondary hæmorrhages are more prone to follow amputations made by this method, although by proper care in the act of ligation, and with sufficient compression of the stump with the dressing this can usually be avoided. The circular operation commends itself, owing to the facility with which it can be executed, even by a novice in the operative art, and by its special applicability for amputations in certain parts, as in the forearm and lower part of the leg. Where the operator can choose his method, amputations may be made with good results as follows: In the arm and forearm, by circular method or rectangular flaps; in the upper part of the leg, by tegumentary and rectangular flaps (lateral or antero-posterior); in the lower part of the thigh, antero-posterior muscular flaps; in the middle of the thigh, by one tegumentary flap raised from the anterior surface of the limb. The oval method will be found particularly applicable to amputations at certain articulations, while the method of Teale, which has not been extensively practised in this country, will give good results in amputations of the leg and forearm where the injury or disease has invaded a limb more extensively on one side than on the other.

LIGATION OF VESSELS.—When the amputation proper is completed, the entire attention of the operator must at once be directed toward permanently controlling the hæmorrhage. For this purpose it is best to grasp the divided blood-vessels, one after another, as they are seen, with hæmostatic forceps, which are allowed to remain in the wound until all the vessels are thus held. This accomplished, the vessels are separately tied with animal ligature or carbolized silk (Fig. 110) In former years it was customary to cut one end of the ligature short, while the other was given sufficient length to reach beyond the angle of the wound.

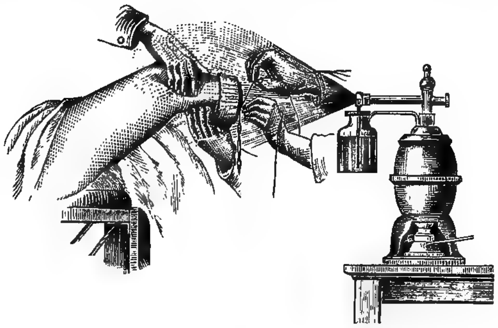

FIG. 110.

At present, most operators, and properly, cut both ends of the ligature short, for it has been well established that the presence of a silk ligature does not interfere with the primary union. This is not the place to dilate upon the material used for ligatures. (See Ligatures.) It will suffice to say that a carbolized silk may be best fitted for tying the main vessel, whereas animal ligatures will answer for smaller arteries. As a rule, not more than four or six arteries will require ligation in all amputations, except those of the hip and shoulder, although long-standing disease (large neoplasms or pre-existing occlusion of the main artery) may have multiplied the number of vessels requiring ligation. Here, as in ordinary wounds, at least the larger arteries should be carefully exposed before the ligature is applied. In the smaller vessels, where their exposure would entail an unnecessary loss of time, portions of the tissues in which they are embedded may safely be included in the ligature by passing this with a needle behind the bleeding vessel. The question has for a long time been discussed as to whether the veins should be ligated. There can be no question but that the ligature of the divided veins removes a common source of secondary hæmorrhage, and materially reduces that immediately following the removal of the Esmarch bandage. The opposition to the ligation of veins in amputations has been mainly based upon the fears of exciting an ascending phlebitis and embolic processes. That these fears are utterly groundless has been conclusively demonstrated. "Of forty cases of ligation of the internal jugular vein, death was fairly ascribable to the ligature in only four, all due to secondary hæmorrhage coming on about the time of the separation of the thread. In not a

single instance was diffused phlebitis excited. In twenty cases of ligation of the external jugular vein, and fifteen of the axillary, additional evidence of the ligation of veins is recorded."[22] The most troublesome hæmorrhage is the parenchymatous oozing which supervenes when the Esmarch bandage is removed. How to contend against this has already been discussed (see above). It is proper to add, however, that in every case the application of an abundance of hot water is of unquestionable value. When the oozing from the divided end of the bone is not checked by this, the medullary canal may be temporarily plugged with clean white wax, or, what is preferable, a mass of carbolized catgut. The accurate closure of the wound and pressure upon it by a well-applied bandage are among the best means of checking the capillary hæmorrhage. When it is necessary to resort to this means, a large sponge is firmly pressed against the wound and retained until the sutures are passed. The sponge being then withdrawn, the sutures are rapidly tightened, while the wound-surfaces are tightly pressed against each other by an assistant.

After-Treatment.—It is beyond the scope of this article to enter into an extended discussion of the various methods of treatment of wounds, although in hardly any other class of wounds are the good or evil results so clearly attributable to the manner of treatment adopted. The question at once presents itself whether the surgeon will pursue a course which will reasonably assure a total, or at least partial primary agglutination of the wound, or whether he will avoid the dangers of retention and decomposition of the secretion of the wound by treating this openly, thus expecting its closure by the slower process of granulation. The latter plan, which is now known as the "open method," was first enunciated by Vezin, Bartscher, and Burow, in Germany (*Deutsche Klinik*, 1856), and disseminated in this country by the late Dr. James R. Wood. When this method of treatment is adopted, sutures, adhesive straps, etc., are entirely dispensed with, the stump being comfortably placed on a pillow or pad, and the wound freely exposed to the air. A cup, or a mass of absorbent cotton, is placed underneath the stump to catch the discharges from it. Twice daily the wound is irrigated with an antiseptic solution, usually of carbolic acid, until at the termination of the first week, when the process of granulation has been thoroughly established, the edges of the wound are approximated by adhesive strips, care being taken that retention does not occur. The manifest advantage of the "open method" of treating amputation wounds is in the ready outlet which is given to the secretions. Their decomposition in the wound is thoroughly prevented, and the chief factor of septic infection is thus avoided. However admirable the results which have been obtained from it,[23] the length of time required for the closure of the wound (six to twelve weeks) militates against its general adoption. While incomparably better than the older methods of tightly closing the wound regardless of proper drainage, the open treatment of wounds has subserved its purpose, and has yielded to the superior advantages of the antiseptic method, which strives to obtain the ideal of the surgeon in the treatment of wounds, viz., primary union. The open treatment of amputation-wounds has been therefore properly relegated to those cases in which the surgeon is convinced that, from the condition of the parts in which the operation has been made, or from the general condition of the patient, primary union cannot take place.

Therefore, in most amputations, the operation is not completed until measures have been taken for the efficient drainage of the wound and the close approximation of its surfaces. The first object is accomplished by the insertion of soft rubber, decalcified bone, or glass drainage-tubes, which are made to pass through the deepest portions of the wound, projecting from this at its angles. For reasons that are apparent, it is always advisable to place the tube in close proximity to the divided end of the bone. Where, as in the case of amputations of the heel (Syme), thorough sewerage cannot be obtained through the angle of the wound, one of the flaps can be perforated in such a manner as to permit the passage of the tube. When long anterior flaps have been used, the tube can even be dispensed with, since the position of the wound is such that the secretions would be naturally removed. Too much importance cannot be given to the matter of drainage, since the chief factor in the prevention of primary union must be sought in an accumulation of bloody serum which mechanically separates surfaces which ought to be held in apposition. When, therefore, the drainage of the wound has been properly cared for, the wound is to be closed by sutures. The material to be used for this purpose may be carbolized silk, silver-wire, or catgut. It is always advisable to introduce one or two deep sutures, which should pass through the soft parts just beneath the end of the bone, and for these either a strong silk or a silver-wire should be used. These deep sutures not only insure an approximation of the soft parts along the entire length of the wound, but they also materially assist in securing drainage. For the superficial sutures, which should be introduced at intervals of half an inch, either catgut or silk should be used, the latter being probably preferable. The superficial sutures may with safety be removed after the third or fourth day, the deeper ones being allowed to remain several days longer. With the closure of the wound, the stump, after being thoroughly cleansed, is prepared to be dressed in such a manner as to prevent the ingress into the wound of those micro-organisms which are now almost universally conceded to be the chief element in the causation of suppuration and its many dangerous consequences. That this entrance of deleterious germs can be best prevented by the use of any of the modifications of the antiseptic method there can be no question. Whether this be accomplished by strict adherence to the practices of Lister, or by adopting the method of M. Guérin and encasing the stump in a dense mass of cotton, is comparatively unimportant, When Listerism is adopted, a narrow strip of "protective," moistened in a three per cent. solution of carbolic acid or in a 1 to 10,000 solution of corrosive sublimate, is placed in contact with the line of union. This and the stump are then covered with one or more layers of carbolized gauze, or one saturated with iodoform or corrosive sublimate. Upon this follows a layer of "mackintosh," and finally five or more thicknesses of gauze, the dressing being retained by a layer of similar material. In resorting to this method, care should be taken to include the joint above the seat of amputation in the dressing. The first dressing is permitted to remain until it becomes stained or until constitutional evidences indicate that some unfavorable process in the stump requires investigation. Even in amputations of the thigh union by first intention is not infrequently achieved, while in many instances, not more than two or three dressings of the stump are required. When the surgeon decides upon the method of Guérin, drainage-tubes can be dispensed with, masses of cotton being applied to the upper and lower surfaces of the stump. These are held in position by narrow cotton strips. Upon the outside of these the stump is covered with sufficient cotton to make the diameter of the stump when dressed three times that of the limb itself. The cotton is then retained by numerous turns of an ordinary roller-bandage. The dressing is allowed to remain for many days, and need not be changed until a decided odor indicates the decomposition of the retained fluids.

When the facilities for the more complicated dressings of the stump are wanting, simpler dressings can be resorted to. Among the vast number which have been advocated from time to time, none commends itself more than that with pure laudanum, so highly lauded by Dr. Pancoast and Dr. Ashhurst. We quote the latter ("Encycl. of Surg.," vol i., p. 599), as follows: "The laudanum is certainly antiseptic from the alcohol which it contains, and its use is certainly very soothing to the patient; it prevents to a greater extent, if not entirely, that painful jerking of the stump which is so apt to follow amputation. At the second dressing, forty-eight hours after the operation, I commonly substitute diluted alcohol for the laudanum, and continue this dressing

until the wound is entirely healed, after which the ointment of the oxide of zinc may be employed instead. Whatever material be employed for the dressing, this must be kept moist, otherwise it will adhere to the edges of the wound and produce irritation. This object is best accomplished by saturating, with whatever preparation is employed, a large piece of lint, laying it underneath the stump, folding it over the end, and then again (doubled) from either side, so that on top of the stump are placed five layers of wet lint, constituting a reservoir from which the medicated fluid is gradually drawn downward. The whole should be covered, moreover, with oiled silk or some other impermeable tissue, which will keep the part moist for at least forty-eight hours." (See also article, Wounds.) Whatever method of treatment be adopted, the stump should be placed in an easy position on a pillow or in a well-padded posterior splint. It is usually advisable to elevate this to a degree sufficient to facilitate the return of blood through the veins.

After amputations where the after-treatment has been successfully carried out, even the largest wounds will often heal entirely by first intention. The dissimilarity of tissues which are often brought in contact with each other in an amputation-wound, and which were formerly supposed to preclude the possibility of immediate union, is no obstacle to the achievement of this result. Of greater importance are the novel relations of the blood-vessels to each other. The circulation of the veins of the stump have lost the *vis a tergo*, so essential to the proper performance of their function, while the smaller arteries are distended with blood in consequence of the interrupted circulation in the main vessel. It is for this reason that, no matter how successfully the after-treatment be conducted, a marked œdema and congestion will manifest itself in the stump. Synchronous with this manifest appearance on the exterior is a transudation of serum loaded with leucocytes in the wound itself. When efficient drainage has been achieved, this does not interfere with primary union. Failure of this measure places the wound in the most favorable condition for extensive inflammations, which, when once established, invariably terminate in suppurations, more or less localized gangrene of the soft parts, or necrosis of the end of the bone. The suppuration is particularly prone to extend along the intermuscular connective-tissue spaces, so that when the process of repair is fully established, muscles, intermuscular spaces, bone, and subcutaneous cellular tissue, are covered by a layer of granulations which renders the underlying parts indistinguishable, and for the permanent cicatrization of which many weeks, or even months, will be required.

In whatever manner the wound heals, certain marked changes will occur in the stump. The muscular tissue undergoes atrophic changes, its fibrous elements becoming firmly adherent to the end of the bone. This itself gradually decreases in size, the end becoming rounded off and often covered by a rounded osteophyte formed from the periosteum or from the granulations springing from the medullary canal. Where two bones are present an irregular osseous bridge not infrequently unites them (see Gueterbock, *P.*, *Arch. f. Klin. Chir.*, Bd. xv. and xvii.). As a rule, the end of the bone is intimately united to the soft parts covering it, although at times a mucous bursa is developed between them. The ligated vessels are converted into firm fibrous cords for a varying distance, and are reduced in size not only in the stump, but in the entire limb. Thus, in amputations of the leg, the artery and vein are reduced over one-half in size, as high as the inferior vena cava and the bifurcation of the aorta.[24] The divided nerves lose their nervous elements by atrophy, while their connective-tissue components increase in numbers until their extremities are often expanded and bulbous, thus forming false neuromata.

Complications.—Pain and muscular spasm may be said to be present to a greater or less degree after every major amputation. They usually supervene soon after the patient regains consciousness, and may develop to a distressing severity, particularly in persons of a nervous and irritable disposition. For the relief of these symptoms hypodermatic injections of morphia act most promptly. The jactitations of the stump are most successfully overcome by lightly fastening the stump with a few turns of a bandage to a well-padded posterior splint.

Inflammation of a moderate degree may be said to be necessary to the process of repair. Unfortunately, this limit of safety is very often passed, when it may lead to extensive suppuration, limited sloughing, or mortification of the stump. The causes which conduce to this untoward complication have already been alluded to. When such severe inflammation attacks the wound, the stump becomes exquisitely sensitive and hot, and assumes a dusky red and glistening appearance. The discharges from the wound are scant and offensive, while the elevated temperature, and hard and rapid pulse sufficiently indicate the constitutional disturbances. When the inflammatory process extends along the intermuscular spaces the limb becomes sensitive to the touch, and swollen for a considerable distance above the seat of operation. When suppuration ensues all may yet be well. On the other hand, the exudation into the tissues may develop in proportions incompatible with the vitality of the parts, when extensive sloughing, and even gangrene of the entire stump may result. The treatment of these conditions must be conducted upon established antiphlogistic principles; iron, quinia, salicylates, and alcoholic stimulants are almost always indicated. For the local condition nothing answers so excellent a purpose as measures which relieve the tension. Stitches, when too tight, must be removed, and as soon as a suspicion of purulent accumulation is aroused, free incisions are to be made. When such extensive suppuration has supervened it is advisable to remove all constricting dressing, and treat the wound by the open method, covering it with iodoform or boracic acid, and removing sloughs as fast as they are formed. As an especially dangerous seat of inflammation the medullary canal of the bone must be referred to. Periosteo-osteomyelitis is particularly prone to follow amputations made for gunshot injuries. It usually manifests itself during the first week after the operation by a brownish or greenish appearance of the medulla, the bone appearing dull and devitalized, the periosteum detached from its surface. The pain is usually very severe, and associated with it are the well-known symptoms of systemic affection, *i.e.*, rigors, elevated and irregular temperatures, diminished secretion of the kidneys, and a dry and thickly coated tongue. Not only does this condition lead to extensive necrosis when recovery ensues, but frequently death results from the absorption of the pus which is retained in the medullary canal. The only measures that offer any hope for this condition are in scooping out the bone-cavity with a sharp spoon, and if this prove unavailing, to resort to a second amputation at the nearest joint. However desperate this procedure may be, a very large number of cases have been reported in which lives have been saved which, without it, would have been inevitably lost.

As a sequel of moderate inflammation of bone, necrosis of its extremity is not infrequently encountered. If this necrosis be limited to the divided end, this condition does not interfere with the primary union of the greater part of the wound. The existence of such a superficial sequestrum can be deemed probable, when after the permanent closure of the wound, a fistulous tract continues to discharge more or less pus. Its actual presence can always be recognized by the cautious use of a probe. When the sequestrum is of larger proportions, numerous fistulous openings will usually be found in the soft parts, which are then more or less adherent everywhere to the bone. The treatment of this condition must be palliative until nature has completely separated the sequestrum, when it can ordinarily be removed with little difficulty by laying the fistulæ freely open. When the sequestrum is large it occasionally becomes necessary to resort to a formal sequestrotomy for its removal. In a very small proportion of cases the irritation consequent upon the long-standing discharges from the necrosis of the bone

gives rise to epithelioma of the latter, for the relief of which a second amputation is usually necessary.

One of the most dreaded complications of an amputation is hæmorrhage. It may supervene within a few hours after the completion of the dressing, or as late as the third or fourth week. The sources of early and late hæmorrhages after amputations differ materially. The former arise from small arteries or veins that have escaped ligation, from arteries divided above the ligature, or from the divided capillaries of the muscles. This condition is readily recognized by the staining of the dressing, the distended appearance of the stump, and the flowing of blood from a number of places where the edges of the wound have been separated. The rapid distention of the stump and the bright hue of the blood which is discharged, at once indicate the arterial source of the hæmorrhage. The darker appearance of the blood, and its appearance in a sluggish stream sufficiently indicate its venous origin. When the hæmorrhage is slight, and particularly if it can be recognized as venous, elevation of the limb and the application of ice may suffice for its control. When it becomes evident that such simple measures are futile, the wound must be reopened, the coagula removed, the bleeding vessel found and ligated. When it is found that the hæmorrhage has come from the medullary canal, this must be treated in the manner already described. The hæmorrhages which supervene during the second week, or even later, usually result from the softening of the plug that occluded a ligated vessel or from erosion of the latter from primary disease of the vessel-wall or from its being bathed in pus. By cutting short both ends of the ligature the necessity for the "cutting through" of the latter is done away with and, at least, one important factor in the causation of late hæmorrhages is thus removed. For the relief of late hæmorrhages compression of the artery by a compress and firm bandage should first be tried. When this proves unsuccessful, pressure should be made at different points of the main artery to determine the point nearest the stump where the hæmorrhage can be controlled. Here the artery is to be exposed and ligated, or, what seems to be preferred by most recent writers, it may be included in the pressure of an acupressure-needle. In extreme cases it may become necessary to resort to re-amputation.

A peculiar and very rare condition of the stump is the development in it of a dilatation of the blood-vessels, commonly in the form of an aneurismal varix. Cases of this nature have been recorded by Cadge, of Norwich, England, Gross, and Agnew. Whereas, in some cases of this kind, operative treatment would not be called for, in others it may become directly indicated. Thus, in the case of Gross ("System of Surgery," vol. i., p. 530), ligation of the femoral was deemed necessary. The operation resulted fatally, from secondary hæmorrhage, on the sixth day.

The form of the stump very frequently gives rise to considerable annoyance and suffering. A healthy stump should present a nicely rounded outline, with the bones hidden beneath and away from the cicatrix. From a variety of causes this normal appearance of the stump may give place to prominence of the bone, retraction and ulceration of the soft parts covering it, and uselessness of the part for locomotion. Such an abnormal condition is commonly known as the "conical" or "sugar-loaf" stump. It may result from an insufficiency of flap, from inordinate retraction of the soft parts, or from gangrene of the integument alone. It is a condition which is more likely to follow the circular and tegumentary flap amputations, although with ordinary precautions it would seem that amputations in healthy tissues should not result in a badly formed stump. When this condition does result, nevertheless, its treatment must vary according to the extent of the deformity. When from an insufficiency of flap or excessive retraction of the soft parts, the end of the bone assumes a too prominent position, the flaps can be drawn down by appropriate bandaging, from above downward, or by the aid of adhesive straps and weights extension may be made in such a way as to cover the end of the prominent bone with integument (Fig. 111). When, notwithstanding these measures, the proper relation between bone and soft parts cannot be brought about, nothing remains but to enlarge the wound, remove the periosteum from the bone, and divide this several inches above the level of the first section.

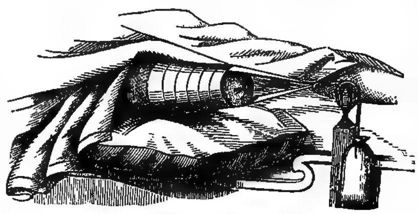

FIG. 111.

It is unnecessary to defer this until the first wound has cicatrized. In extreme cases of conical stump re-amputation will be indicated. It can be more highly recommended since re-amputation is not often followed by bad results. Mr. Bryant[25] refers to a very interesting condition of amputation-stumps in children, in whom the development of conical stumps may be in a measure expected, since, in the process of growth, the bone appears to develop more rapidly. In the case of a boy whose leg was amputated, he found it necessary on two occasions, at intervals of three years, to remove two pieces of bone at least an inch long.

Neuroses of the stump are among the most intractable of its diseases. They may appear in the form of severe neuralgias, or in the form of spasmodic muscular contractions. The former condition usually depends upon an adherence of the divided nerves to the bone or the cicatrix, while in exceptional cases it results from the bulbous enlargement of the extremities of the nerve. For the relief of the former condition, subcutaneous division of the adherent cicatrix must be practised. Where neuromata can be felt, these are to be removed; when, from the number of these enlargements, or from their deep positions, this procedure is impracticable, nothing short of a re-amputation will give relief. Continuous jactitations, or "chorea" of the stump, as it might be termed (Gross), is very rarely encountered. It is more prone to develop in the thigh than elsewhere. The stump, when thus affected, is the seat of a constant tremor, often sufficiently extensive to be noticed when covered. In a case of this character which I saw two years ago, and which involved the thigh in an otherwise healthy subject, the spasm continued, notwithstanding all efforts to allay them. The most efficient measure was the deep injection of ether, which would relieve the spasm for about two weeks at a time, when the injection had to be repeated.

PROGNOSIS AND MORTALITY.—In estimating the inherent dangers of the operation we must take into consideration only those cases in which the individuals operated on were—aside from the lesion which necessitated the operation—in the enjoyment of comparatively good health. As it is incorrect to attribute the immense mortality of tracheotomy for diphtheritic croup to an operation which, if performed for the removal of foreign bodies, is almost always successful, so it is manifestly improper to attribute most deaths after amputation to the operation itself. A compilation of the amputations of "expediency," made in Guy's Hospital, indicates a mortality of 26.8 per cent. If we remember, however, that these statistics of Bryant and Golding-Bird include amputations made for neoplasms, and that the most valuable methods of after-treatment were at that time not employed in the hospital in question, this percentage must be misleading as to the inherent dangers of amputations. That the mortality of the operation under favorable circumstances can be greatly reduced from the percentage above given can be easily demonstrated. Thus, of 716 late and pathological amputations collected by Sir James Y. Simpson[26] from smaller hospitals and private practitioners of Scotland and England only 74, or nine per cent., died. Of 100 amputations (including 39 of the thigh), made by Bruns,[27] only 12 terminated fatally. Finally, of 187 amputations made by Volkmann,[28] for disease, only 7 succumbed (three

per cent.). This number includes 74 amputations of the thigh, with only two deaths.

Unhappily, these statistics are largely at variance with those gathered either from large hospitals or from the battle-field. Thus, of 560 larger amputations for all causes collected by Malgaigne in the hospitals of Paris, 299 ended fatally, the mortality being fifty-three per cent. The fatality attending amputations by English surgeons in the Crimean campaign[29] is represented by 426 operations, with 169 deaths (39.6 per cent.), while the figures of the French surgeons during that war are 4,390 amputations, with 3,218 deaths, giving the appalling mortality of seventy-three per cent. Compared with such results those obtained during the war of the Rebellion show a most decided improvement. Of 29,980 amputations, the result was determined in 28,261; of these, 20,802 recovered. There were 7,459 deaths, thus yielding a mortaliy of 26.3 per cent.[30] This is about the fatality that attends amputations in civil practice in the larger hospitals of this country and of England, although occasionally better results are recorded. Thus, of 100 amputations made in the Pennsylvania Hospital (1874–78) only 17 died, while of 539 amputations made for all causes in St. Bartholomew's Hospital (1873–82) only 88 died, giving a mortality of 16.3 per cent.

It is not the least important achievement of Malgaigne to have directed the attention of surgeons to the chief causes which modify the prognosis in the individual case of amputation, and how, therefore, statistics must vary according to certain now well-known conditions under which they are collated. In a somewhat similar direction were the investigations of Simpson. The conditions which influence the prognosis of amputations will now be considered in the order of their importance.

Age.—The mortality of amputations is determined more by age than by any other one factor, since they are better borne in childhood and adolescence than later in life. Malgaigne was the first to point this out by the tabulation of 560 cases in which the mortality steadily increased with the age of the patients. Amputations between the ages of five and fifteen years yielded a mortality of 33 per cent., those between fifty and sixty-five of 71.4 per cent. Similar investigations have been made by Callender, Holmes, Bryant, and Golding-Bird in England, and by Morton and Ashhurst in this country. The last-mentioned author[31] has combined the statistics from various sources, and, after the manner of Mr. Holmes, divided life into three periods of twenty years each. The total number of cases thus tabulated is summarized as follows:

TABLE SHOWING PERCENTAGE OF MORTALITY AT DIFFERENT AGES.

Whole number of cases.	Mortality below 20 years.	Mortality between 20 and 40.	Mortality over 40 years.	General death-rate.
2,649	16.7	30.1	43.4	29.4

TABLE SHOWING PERCENTAGE OF MORTALITY BEFORE AND AFTER THIRTY YEARS OF AGE.

Whole number of cases.	Mortality below 30 years.	Mortality above 30 years.	General death-rate.
1,805	19.2	37.4	26.7

The comparatively excellent results after amputations in children must be attributed to the rapidity with which even large wounds unite in them, to the resistance which their ordinarily unvitiated constitutions offer to septic processes, and to their freedom from visceral complications. The ease with which even large amputations are supported in childhood was particularly impressed on the mind of the writer by the case of a lad of seven, in whom he had amputated below the shoulder for railway injury. Because he was not given the freedom of the ward, the boy escaped from the hospital (Good Samaritan, in Cincinnati) on the eighth day after the operation. The wound had healed *per primam.*

The very unfavorable results which follow amputations in advanced life are readily accounted for by the reduced vitality of the system at large, by the imperfect nutrition of the stump from impaired integrity of the blood-vessels, and by the rapidity with which these patients succumb to septic infection. It is extremely probable that if the latter could be prevented the marked influence of advanced life on the results of amputations would be materially lessened. Thus of sixty-one uncomplicated amputations made by Volkmann, in persons over fifty, only 4.8 per cent. died. Among these was a successful amputation of the thigh for injury in a man eighty-four years of age.

Seat of Operation.—The danger of an amputation always increases with the size of the wound and its proximity to the trunk—amputations of the lower extremity yielding a greater mortality than those of the upper. Since about thirty-two per cent. of the deaths following amputations are directly attributable to the combined shock and hæmorrhage consequent upon the injury and the operation, it is easily understood why the mortality varies in the manner indicated. The dangers of septic infection also increase with the size of the wound, and when amputation wounds fail to unite by primary union, death often results from the exhaustion consequent upon protracted suppuration. The situation at which the bone is divided also materially influences the result. The opening of the medullary cavity of a large bone like the femur, or tibia, is more apt to be followed by osteomyelitis and its consequences than is the division of the bone through its articular end. This is well shown by a comparison of the results of amputation through the lower third of the thigh and through the femoral condyles, the former operation yielding a mortality of 39 per cent. against 29 of the latter.

The ratio of deaths following amputations for injury and disease in different parts of the body is well illustrated in a subjoined table from large hospital reports, issued within the last two decades. For exceptional operations (hip-joint and elbow) reports of cases from private practice were included. This doubtless explains the apparently greater mortality of amputation of the thigh than of the hip, since relatively more successful than unsuccessful cases are thus recorded.

TABLE I. (From Max Schede).[32]

	AMPUTATIONS FOR INJURY.			AMPUTATIONS FOR DISEASE.		
	Total number of cases.	Number of deaths.	Mortality per cent.	Total number of cases.	Number of deaths.	Mortality per cent.
Amputation—						
at hip-joint	55	39	70.9	153	65	42.6
of thigh, upper third	73	57	78.0	42	15	35.7
of thigh, middle third	67	50	74.6	137	55	40.1
of thigh, lower third	149	74	50.	205	64	31.
of thigh through condyles	136	44	32.3	79	20	25.4
of thigh, locality not specified	1,384	664	48.	2,494	817	32.7
at knee	314	103	32.8	123	30	24.4
of leg, up. and middle third	130	54	41.5	178	44	24.7
of leg, lower third	33	3	9.1	128	19	14.
of leg, locality not specified.	1,956	785	40.	1,695	215	12.7
of foot, partial	223	45	20.2	562	70	12.4
at shoulder-joint	274	116	42.3	118	33	28.
of arm	1,167	364	31.2	441	81	18.4
at elbow-joint	23	6	26.	8	1	12.5
of forearm	1,316	143	10.8	506	62	12.2
at wrist	199	5	2.5	27	.	..
of fingers and toes	337	6	1.8	320	6	1.8

Nature of Lesion.—Very potent in its influence on the results of amputations are the causes for which they are made. When the operation is resorted to in an individual who, while in perfect health, has received a severe injury from which he has probably lost a considerable amount of blood, the prognosis is much less favorable than when it is made for disease. This applies particularly to am-

putations after railway injuries and traumata inflicted by heavy machinery. The shock and hæmorrhage are very often so severe that death results within a few hours after the operation. The prejudicial effect of a trauma on the results of amputations is still further enhanced if the subject is addicted to intemperate habits. This was well illustrated in our recent riots (Cincinnati, 1884). Those injured were for the most part more or less under the influence of alcohol when wounded, and four-fifths of those in whom amputations were made succumbed.

It will be seen from the table given below that the statistics indicate with remarkable uniformity the greater mortality of amputations when made for injury than when made for disease. The explanation generally offered for this feature of the prognosis of amputations is that patients who have for a long time been subjected to suppurative processes (necrosis, caries, etc.), are so inured to suffering that they bear the shock of an operation comparatively well, and that they are less prone to septic infections which are so often the immediate causes of death after amputations for trauma. The correctness of this view is substantiated by the fact that about seventy-five per cent. of so-called pathological amputations are made for chronic inflammatory conditions of either bones or joints, and that under these circumstances the soft parts are usually more or less atrophied, and yet at the same time densely infiltrated with a connective-tissue growth which, when divided in an operation, presents a barrier to the absorption of deleterious elements. It is noteworthy, as Mr. Bryant[33] has pointed out, that this infiltration of the soft parts does not necessarily interfere with the ready union of the wound. While amputations for chronic affections of the nature indicated terminate fatally in only 14 per cent. of the cases, those made for deformity and neoplasms present a mortality of 26.8 per cent. and 46 per cent. respectively (Golding-Bird and Spence).

TABLE II.

Authority.	Amputations for Injury.			Amputations for Disease.			Total Amputations.		
	Number of cases.	Number of deaths.	Mortality, per cent.	Number of cases.	Number of deaths.	Mortality, per cent.	Number of cases.	Number of deaths.	Mortality, per cent.
Malgaigne[1]	182	117	64	378	182	48	560	299	53
Guy's Hosp. Rep.[2]	447	201	45	679	147	22	1,126	348	31
Chadwick[3]	846	202	24	524	102	19	1,370	304	22
Billroth (1860–67)[4]	106	57	54	58	18	31	164	75	46
Wilms[5]	144	58	40	94	32	33	238	90	38
Lücke[6]	28	21	75	52	25	48	80	46	57
Volkmann[7]	130	24	19	187	7	3	317	31	9+
Ashhurst[8]	72	24	33	28	4	14	100	28	28
Spence[9]	186	77	41	371	73	19	557	150	27
Glasgow Inf.[10]	388	126	32	338	40	12	726	166	23
Leeds Inf.[11]	355	84	24	305	48	16	660	132	20
St George's Hosp.[12]	159	72	46	409	99	24	568	171	30
St. Barth. Hosp.[13]	115	33	29	424	55	13	539	88	16
Total	3,158	1,096	34.7	3,847	832	21.6	7,005	1,928	27.5

[1] Malgaigne: Arch. Gén. de Méd., 1842, 14, p. 52.
[2] Guy's Hospital Reports, published statistics of vol. xxi., 3d S., to which cases since reported have been added.
[3] Amputation, statistics of, in four American hospitals.
[4] Statistics of Surg. Clinic of Zürich. Langenbeck's Arch. f. Chir., vol. x.
[5] P. Güterbock: Statistics of Bethanien, Langenb. Arch. f. Chir., vol. xxii., p. 80.
[6] Lücke: Statistics of Hospitals of Berne. Zeitschr. f. Chir., vol. ii., p. 380.
[7] M. Oberst: Die Amputationen in d. Volkmann'schen Klinik. Halle, 1882. Statistics rearranged to suit this table; 57 complicated cases with 17 deaths are included.
[8] Ashhurst: Encyclop. of Surg., vol. i.
[9] Spence: Med. Times and Gazette; Edinb. Med. Journ. Ashhurst in Internat. Encyl. of Surg., vol. i.
[10] Amputations for eight years, ending December 31, 1881, M. Thomas: Lancet, 1882, vol. i., p. 1,067.
[11] Amputations in the Leeds Infirmary by Thomas Nunnely, Lancet, 1870, vol. i., p. 153.
[12] T. Holmes: St. George's Hospital Reports, vols. i. and viii. Also vols. ix. and x.
[13] St. Bartholomew's Hospital Reports, vol. xix., Stat. Tables, p. 92.

After-treatment.—A comparison of the statistics from the Parisian hospitals (Malgaigne) and those of St. Bartholomew's Hospital, clearly shows that the mortality of amputations is gradually diminishing. Whereas a large part of this reduction is attributable to the general use of anæsthetics, most credit must be given to improved methods of after-treatment, the term being used in its widest sense. If the mortality of amputations in large hospitals is still from thirty to forty per cent., it is because the atmosphere of the overcrowded wards is laden with the germs of erysipelas and pyæmia. Sir James Y. Simpson directed the attention of surgeons to the pernicious influences of the wards of large hospitals, when he compared the disastrous results there obtained (40 per cent.) with those obtained in private practice, in the country, and in small hospitals. Of 1,382 amputations made for injuries only 152 died (11 per cent.), while 716 operations were made for disease with only 74 deaths (10 per cent.). Mr. Burdett[34] has recently shown that the mortality of the smaller hospitals (averaging ninety beds) of England does not exceed 17 per cent. On the other hand, in 1859 Mr. Bryant, in a report from Guy's Hospital to the Royal Medical and Chirurgical Society, attributed 33 out of 76 deaths (43 per cent.) to pyæmia, and the appalling statistics of Billroth in Zürich, and Lücke in Berne, speak even more forcibly against this chief factor in the causation of death after amputations. Since the principles of cleanliness and thorough ventilation have been better understood and regarded in the management of even large hospitals, the mortality from pyæmia, erysipelas, and gangrene has been gradually reduced. Thus, in Guy's Hospital, from 1861 to 1868, only 39 out of 119 deaths (32.7 per cent.) resulted from pyæmia, while at a still later period (1869 to 1878), only 23 per cent. could be ascribed to this cause. During a part of this time the antiseptic method was resorted to by some of the surgeons of the hospital in question.

The improved methods of treating the stump next merit consideration, as having very materially contributed toward diminishing the mortality after amputations. If all hospitals, as they do, show an improvement in their results obtained after amputations, it is only an evidence of the fact that the principles of properly draining a wound have become generally recognized, and that if the deleterious influences of a vitiated atmosphere manifest themselves, nevertheless, in a wound, the process remains localized in it; although suppuration occurs, it, as a rule, does not lead to septic infection.

In no other class of wounds has the influence of the antiseptic treatment been so much considered as in those made by the amputating knife. To the unprejudiced observer there can be no question but that, under Listerism, better results can, as a rule, be obtained, at least in large hospitals, than by other methods of treatment. The evidence in proof of this is convincing. Thus the statistics of the Surgical Clinic of Basle for periods of ten years before and after 1870, when the antiseptic method was introduced, are in most marked contrast. From 1861 to 1870, 36 amputations were made for injuries, with a mortality of 41.6 per cent. From 1871 to 1880, 46 amputations were made for the same cause, with a mortality of only 15.2 per cent. From 1861 to 1870, 28 amputations were made for disease, with a mortality of 44.4 per cent., whereas of 93 pathological amputations made from 1871 to 1880, only 9.6 per cent. terminated fatally. The terrible mortality of amputations experienced by Billroth, in Zürich, from 1860 to 1867, has already been referred to (see Table II.). Under an imperfect antiseptic method, the mortality of his amputations in Vienna was reduced to 29.7 per cent., whereas, under strict Listerism, from 1877 to 1880, of 91 larger amputations only 19.7 per cent. succumbed.[35] Similar experiences can be gathered from English hospitals. For three years prior to 1876, under ordinary methods of treatment in the Infirmary at Newcastle-on-Tyne,[36] 49 out of 98 major amputations terminated fatally (50 per cent.). In three years subsequent to the introduction of the antiseptic method, only 13 deaths resulted from 108 amputations, the mortality being thereby reduced to 12 per cent

The mortality of amputations in the Glasgow Infirmary prior to 1869, was 39.1 per cent. From 1873 to 1881, under strict Listerism, it was reduced to 22.8 per cent.[37] From these statistics it becomes evident that where the mortality after amputations in large hospitals is great, it can be materially reduced by the introduction of the antiseptic method, and the duty of the surgical staff of such institutions is therefore clearly defined.

On the other hand, very excellent results are obtainable without the antiseptic method. Thus, of 539 amputations made at St. Bartholomew's Hospital, only 88 ended fatally (16 per cent.), and of 100 amputations treated in the ordinary way in the Pennsylvania Hospital, only 17 died. While these are remarkable results, they cannot bear comparison with those achieved by Volkmann and Bruns with the antiseptic method. Of 100 amputations made by the latter, including 39 of the thigh, only 12 died. Of 317 amputations made by Volkmann, including 112 of the thigh, only 9 per cent. terminated fatally. Of the amputations of the thigh, 112 in number, 16 died (14 per cent.), although in this number are included 27 amputations of the thigh in subjects who were already septic at the time of operation, and of whom 12 succumbed. The average age of cases of amputation of the thigh was thirty-six. Of 73 primary amputations for injury in uncomplicated cases, including 11 of the thigh (with 2 deaths) and 3 of the hip (all fatal), there were 7 deaths (10 per cent.). Unprecedented results like these, demonstrate beyond doubt, that except in amputations that end fatally from the shock of the injury, the mortality depends largely upon the surgeon's ability to keep the wound aseptic. (See articles Antiseptics in Surgery and Wounds.)

Multiple Amputations.—While it is comparatively rare that disease or injury affects more than one extremity, in a degree sufficient to warrant double amputations, these are nevertheless occasionally required. It is self-evident that they are of the gravest importance and present a most unfavorable prognosis, on account of the shock associated with the injury. Of 28 double amputations made in the Western Pennsylvania Hospital,[38] 27 were for railroad accidents, and 15 of the patients died. The fact that eleven of the deaths occurred in the first forty-eight hours shows that they were due rather to the injuries than to the amputations. When multiple amputations are made for disease, which is in about ten per cent. of all cases, it is usually for frost-bite.

Multiple Amputations in Military Practice.[39]

	Number of cases.	Recovery.	Deaths.	Undetermined.	Per cent. of mortality.
Both amputations in the upper extremity......	47	31	16	..	34
One amputation in upper, one in lower extremity..........	43	21	21	1	50
Both amputations in lower extremity..........	82	31	50	1	61.7
Total....	172	83	87	2	51.1

Multiple Amputations in Civil Practice.

	Number of cases.	Recovered.	Died.	Mortality, per cent.
Thighs..........	18	3	15	83
Thigh and leg..........	21	9	12	57
Thigh and arm..........	5	2	3	60
Thigh and forearm..........	7	4	3	43
Leg and leg..........	42	20	22	52
Leg and arm..........	11	6	5	45
Foot and foot..........	12	10	2	16
Arm and arm..........	9	6	3	33
Forearm and forearm..........	15	11	4	27
Total..........	140	71	69	49

The mortality attending multiple amputations, it will be seen from the preceding tables, is about fifty per cent., amputations through the lower extremities presenting a greater fatality than those of the upper. The first table illustrates the mortality of these amputations in military practice. The second table, made up from German, English, and American reports of the last twenty years, shows the relative frequency and fatality of multiple amputations as they are made in different parts of the body.

When the necessity for multiple amputations arises, the question must be considered whether they shall be made at the same time, when they are called synchronous amputations, or whether a longer or shorter interval shall intervene between them. In these cases, as in amputations generally, no definite rules can be formulated. In cases of trauma it is generally advisable to make both amputations at the same time, removing the larger member first, but deferring the closure of the wound until both amputations are completed. If, after the first operation the condition of the patient is such as to preclude the possibility of recovery if the second is performed at once, the less injured member must be treated as if the injury sustained by it were of a less degree of severity and justified an attempt at conservatism. In cases of disease affecting several extremities (frost-bite, white-swelling, etc.), it is generally better to observe a sufficient interval between the operations to permit the constitution to rally from the first before the second amputation is made. In these cases the danger of septic infection from the limb that is spared is not as great as in cases of traumatic origin.

Even triple and quadruple amputations are occasionally performed with success. In a case of railway accident, Dr. G. Koehler, of Schuylkill Haven, Pa., in 1867, removed simultaneously, on account of a railway injury, both legs and one arm from a lad thirteen years of age, recovery taking place. Professor Stone, of New Orleans, had a similar case in a man of thirty, the subject of a railway accident.[40] According to Professor Agnew,[41] successful triple amputations were made in York, Pa., in 1868, and Rochard,[42] reported to the Academy the case of De Leseleuc, of Brest, who had successfully amputated a thigh, leg, and arm in a man the subject of trauma. Quadruple amputations, usually made for frost-bite, have been successful in the cases of Muller, of the U. S. Army,[43] Dr. Begg, of Dundee, and M. Champenois, of the French Army. Other cases are referred to by Morand, Longmore, and Southam.[44] M. Larrey mentions two cases, one of which, the case of a soldier who had all his extremities removed by heavy ordnance, he had seen in the "Invalides." The other case, which he had seen in Algiers, was that of an Arab, twelve years of age, who had intentionally placed himself on the track in such a position that a passing train mangled both hands and feet.[45] Still another successful quadruple amputation for frost-bite has recently been recorded by Tremaine.[46]

Individual Amputations.

Amputation of the Fingers.—When the phalanges of the fingers or thumbs are the seat of incurable disease or of severe injury, amputation often becomes necessary. It is well to remember that if the bone of the distal phalanx alone is affected, its natural exfoliation should be awaited, when the soft parts can often be preserved, to the great advantage of the patient. Particularly in the thumb and index finger is it necessary to save as much as possible. In the third and fourth fingers amputation should not be practised at the second joint, since the preservation of the proximal phalanx leaves a part that is ungainly and does not add to the usefulness of the hand. When a portion of a finger requires removal the operation may be practised either at a joint or in the continuity of a phalanx. In both cases it is important to remember that when the finger is flexed the articulations are below the prominences made by the knuckles, the distal, middle, and proximal articulations being respectively one-sixth, one-fourth, and one-

third of an inch below the most prominent lines of the joints. It must also be borne in mind that strong lateral ligaments prevent, until they are divided, the complete exposure of articular surfaces (Fig. 112). When the amputation is to be made at the joint, it can be most expeditiously executed in the following manner: The hand being held in the prone position, the tip of the finger, encased in a rag or piece of lint, is firmly seized by the operator and flexed. With a long and narrow knife an incision is made from side to side over the dorsal surface. By this the joint is at once opened. With two rapid strokes of the point of the knife the lateral ligaments are next severed. The blade of the knife, with edge directed downward, is then placed behind the flexor surface of the phalanx to be removed, from the soft parts of which a well-rounded flap is to be cut from within outward by a sawing movement. The wound presents the appearance shown in Fig. 113. Only when there is an insufficience of flap is it proper to remove the head of the proximal bone. The disarticulation of a phalanx can also be effected by transfixion: the hand being held in a supine position and the finger extended, the latter is transfixed on the palmar side of the bone, just below the fold of the joint; a palmar flap of sufficient length is then made. The flap being held out of the way, the joint is made prominent by hyperextension and opened. The soft parts on the dorsal surface of the joint are then divided by a single sweep of the knife. In amputations of the fingers, the soft parts of the palmar aspect are always preferable for a flap, since the cicatrix is then protected from pressure. Where they cannot be utilized, a dorsal flap can be made, either by transfixion or, what is preferable, by cutting from without. Lateral flaps, single or double, can likewise be utilized in this amputation. In amputations in the continuity of a phalanx the flap may be cut from the palmar aspect by a transfixion, the dorsal surface being divided by a transverse incision, or a second flap may be formed. The circular operation, with longitudinal lateral cuts, may likewise be successfully practised in this position. After the division of the soft parts, the bone must be divided with a metacarpal saw or the cutting forceps. In all amputations of the fingers two digital arteries usually "spirt." Their ligation is unnecessary; the approximation of the wound surfaces generally suffices for their closure.

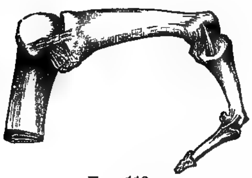

FIG. 112.

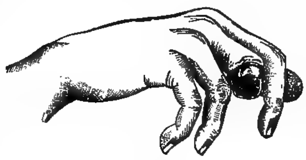

FIG. 113.

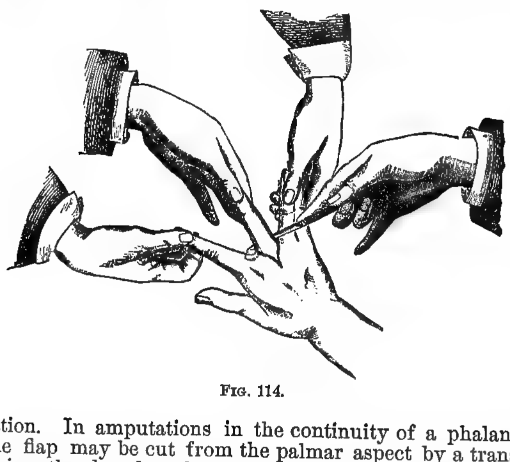

FIG. 114.

Amputation of an entire finger at the metacarpo-phalangeal joint can be readily accomplished as follows: The adjacent fingers being held aside by an assistant, the operator, with his back to the patient, grasps the finger to be removed with the left hand and extends it sufficiently to see its palmar surface. A narrow knife being introduced from the right side divides the soft parts on the palmar surface on a level with the extended interdigital web. The incision is then carried around the right side of the finger (Fig. 114, Esmarch) in a slight curve into the dorsal surface of the head of the metacarpal bone. The knife is then carried around the left side of the finger in the same manner, the ends of the first incision being thus joined. The tendons, lateral ligaments and capsule being successively divided, the disarticulation is completed and a heart-shaped wound left. The margins of this wound come accurately into contact when the remaining fingers are approximated to each other. When comeliness of the hand is valued more than strength, it is best to remove the head of the metacarpal bone with cutting-forceps (Fig. 115), since its preservation usually leaves an unsightly prominence. In persons who do manual labor its removal should be avoided, since it would materially lessen the strength of the hand.

FIG. 115.

The incisions for disarticulations of the thumb, index and little fingers may often be advantageously modified in such a manner as to make two lateral flaps, the longer of which is on the free side of the finger, the shorter being made on the side of the interdigital web. To preserve the symmetry of the hand the heads of the second and fifth metacarpal bones should always be removed by an oblique section when the index and little fingers are amputated. When two or more fingers are to be removed, it can easily be done by making two convex flaps, one on the dorsal and the other on the palmar aspect of the hand, the latter being given the greater length. A flap may likewise be taken from the side of one finger, or rectangular flaps from the opposite surfaces of the fingers that are farthest from each other. In amputations of a number of fingers it is generally best to remove each finger separately, since unnecessary sacrifices for the sake of brilliancy will thereby be avoided and a better result be obtained. When, in consequence of accident or disease, the metacarpal bone must be removed with the finger, the incisions are like those for the removal of an entire finger, only that the dorsal cut must be continued upward toward the wrist for a varying distance, and that the incision around the root of a finger is to be made above the interdigital web. The extensor tendons being divided as high as possible, and the bone separated from its muscular attachments, this is divided with cutting-forceps near its articular extremity or entirely enucleated. When the surgeon has the option, the former practice should be preferred, to avoid opening the articulations of the wrist. Exceptions can be made in the first and fifth metacarpal bones, which, having individual synovial sacs, may be removed without the danger of producing extensive inflammation of the wrist. Amputation of the entire thumb should rarely be practised, for every portion of it that can be saved is of value for opposition to the fingers. When it becomes necessary to remove the thumb with

its metacarpal bone, it is best accomplished by the oval method. The point of a knife should be entered above its articulation with the carpus, and a triangular incision (Fig. 116) made along its radial aspect, the sides of the triangle diverging from each other as they approach the head of the metacarpal bone and becoming continuous with each other in the web and index finger. The muscles being detached and the extensor tendons divided, disarticulation is readily effected by forcibly extending the thumb toward the radial side and severing the ligaments. In disarticulating, the edge of the knife should be kept close to the base of the bone, lest the joint between the second metacarpal and trapezium, and through it the remaining carpal joints, be opened. After this operation a linear cicatrix remains. The most expeditious method of amputating the thumb yet devised is that of Walther, and is admirably suited to cases in which an anæsthetic is not used. The thumb being abducted, the knife is made to cut its way between the first and second metacarpal bones until the base of the former is reached (Fig. 117). The thumb being greatly abducted, the joint between its metacarpal bone and trapezium is opened and traversed. The knife is then carried downward upon the radial side of the bone, where, by cutting outward to the level of the interdigital web a radial flap is made. Amputations of the little finger with its metacarpal bone can be made in the same manner, either by the oval or by the flap method.

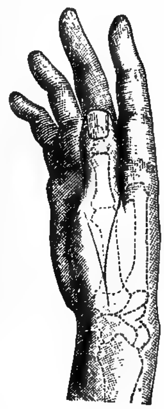

FIG. 116.

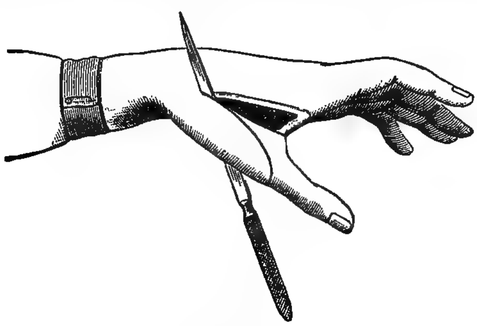

FIG. 117.

Injuries of the palm of the hand are generally of such a nature that by a little ingenuity on the part of the surgeon, part of it can be preserved. When in rare cases disarticulation of the last four metacarpal bones becomes necessary, the thumb being left, it may be done as follows: The hand being grasped and held in supine position, a long, narrow blade is passed through the palm from the base of the fifth metacarpal bone to the web of the thumb. By cutting outward, a broad semilunar flap is made (Fig. 118). An incision is next made on the back of the hand, beginning at the web of the thumb and carried obliquely upward to the upper third of the second metacarpal bone, whence it is continued transversely over the three last metacarpal bones until it meets the palmar flap at the ulnar border of the hand. Both flaps are thus reflected to the carpo-metacarpal joints and disarticulation is effected from the ulnar side, the hand being forcibly abducted.

FIG. 118.

AMPUTATION AT THE WRIST.—In amputations at the wrist the surgeon has the choice of the circular and tegumentary flap methods, both of which leave a very excellent stump.

Circular Method.—Retracting the skin of the forearm with his left hand, the operator carries the knife in a circular sweep around the hand one inch below the styloid processes. The skin and subcutaneous layers being liberated by incisions perpendicular to the axis of the limb as far as the styloid processes, should be reflected like a cuff. The hand being then pronated, and forcibly flexed, the tendons are divided and the joint opened by an incision over the dorsum from one styloid process to the other. In making this incision the convexity of the upper surface of the carpus must be remembered. The lateral ligaments being next severed, the anterior part of the capsule and all the flexor tendons are cut through with one stroke of the knife (Fig. 119).

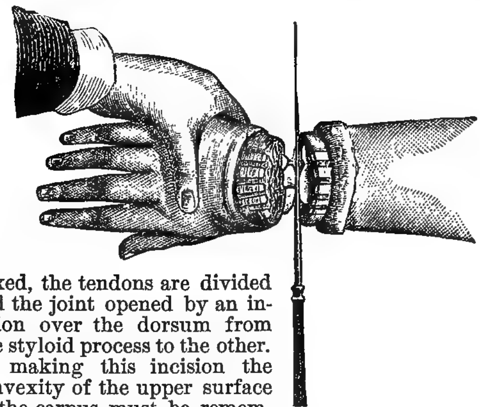

FIG. 119.

Antero-posterior Flap.—The operator seizes the lower part of the pronated hand, and after flexing it makes a semilunar incision over the middle of the back of the hand from one styloid process to the other (Fig. 120). After reflection of the flap the joint is opened as in the circular operation, and the operation is completed by cutting a short palmar flap from within outward (Fig. 121). The projection of the pisiform bone frequently renders this part of the operation embarrassing.

FIG. 120.

Method of Dubreuil.—A very excellent result can be obtained by making a single lateral flap, either from the radial surface of the thumb or from the soft parts covering the fifth metacarpal bone, the former being preferable. As will be seen from Fig. 122, the operation consists in making a semilunar flap with broad base, from the integument which covers the first metacarpal bone, the point of the flap reaching the base of the first phalanx. A transverse incision around the wrist is then made and disarticulation completed as in the other operations.

Amputation of the Forearm may be practised by the circular, tegumentary, or musculo-tegumentary flap methods. The lower third of the forearm, containing a large number of tendons, is ill-suited for the latter method, the circular operation being preferable (Fig. 99). When the integument is greatly infiltrated and the reflection of a cuff is thereby rendered impracticable, tegumentary flaps can be made, the tendons being divided by a circular incision (Fig. 123). The presence of a large number of synovial sheaths, and the danger of inflammations in them when they are opened should not militate against the value of operations in the lower third of the forearm, since, by operating below the insertion of the *pronator radii teres*, movements of pronation and supination will be preserved.

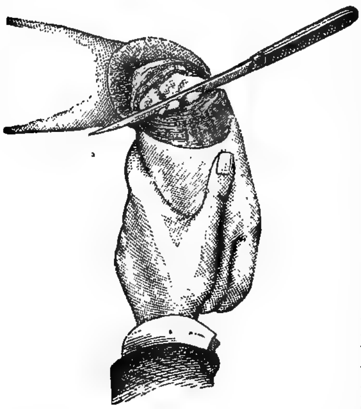

Fig. 121.

A number of surgeons prefer the flap operation in all amputations of the forearm, making both flaps by transfixion in fleshy subjects. Under opposite circumstances the anterior flap can be made in this manner, and the posterior by cutting from within outward. When this method is resorted to, the bones must be divided as high up as possible, to overcome their tendency to protrude at the angles of the wound. Musculo-tegumentary flaps should be used only in the fleshy part of the forearm. In all amputations in this part the catling is to be used, in the manner already described (Fig. 101). The divided tendons and nerves must be drawn from the wound and cut as short as possible. The arteries requiring ligation are the radial, ulnar, and interosseous. It is particularly essential that the latter should be divided *but once*, and carefully secured. When secondary hæmorrhage occurs after amputation of the forearm, it is almost always the result of faulty ligation of this vessel.

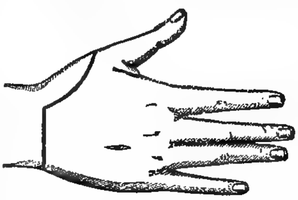

Fig. 122.

Fig. 123.

Amputation at the Elbow.—The removal of the forearm at its articulation with the humerus, is generally acknowledged to have been first performed by A. Paré, in 1536, in the case of a soldier who had received a gunshot wound of the forearm, which was followed by gangrene. The operation did not meet with much favor by surgeons generally, until it was again advised and practised in the second quarter of this century by Textor, of Würzburg, Dupuytren, and Liston. With the exception of Chenu's statistics, the results of amputation at the elbow have been very favorable, the death-rate not exceeding 14 per cent. (Agnew). The last-named writer, however, gives a mortality of 65 per cent. as that which attended disarticulations of the forearm during the Crimea.[47] On the other hand, of 39 amputations at the elbow, made during the War of the Rebellion, in which the result was determined, only 3 succumbed; the mortality being less than 8 per cent.

The operations generally resorted to in amputations at the elbow are the circular and musculo-tegumentary flap methods. When the former is practised, a circular incision should divide the skin and subcutaneous cellular layer of the forearm at least two inches below the humeral condyles. When a cuff of sufficient length has been reflected, the anterior surface of the joint is made prominent by hyperextension, and divided by a transverse cut with the end of the knife. When the lateral ligaments are next divided, the joint surfaces are sufficiently separated from each other to permit the knife to be passed behind the olecranon, where the tendon of the triceps is to be divided. The latter step of the operation is sometimes attended with such difficulty that many surgeons preserve the olecranon process by sawing the ulna transversely after disarticulation of the radius has been effected. The advantages which are to be obtained by its preservation on account of the influence which the triceps will have over the artificial limb, are more than balanced by the increased dangers of retention of secretion in the wound and necrosis.

Excellent results can also be obtained by tegumentary flaps. As represented in Fig. 124 (Esmarch), a curved incision is made over the flexor surface of the forearm, beginning and ending about one inch below the condyles. The large semilunar flap thus made is reflected to its base. A second, but shorter convex flap is made posteriorly, which, when reflected, exposes the olecranon. The operation is then completed by disarticulation, as in that by the circular method. The most brilliant operation, and at the same time a very satisfactory one, is that by which a long anterior flap is made by transfixion. The knife, being introduced a little less than an inch below the external condyle (for the right arm) of the humerus, is pushed directly across the front of the articulation to a point on the same level on the opposite side. The arm being held in a supine position, a broad, almost rectangular flap, from four to five inches in length, is made by cutting outward. The ends of the wound should then be united by a slightly convex incision carried across the posterior aspect of the joint. Disarticulation is then effected as in the previous operations.

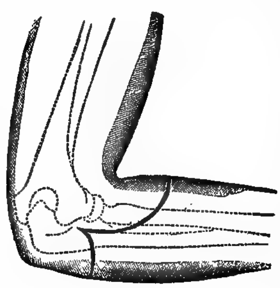

Fig. 124.

When the soft parts of the anterior portion of the forearm cannot be utilized, the integument of the posterior surface can be shaped into an admirable covering for the end of the bone. Ashhurst thus describes the elliptical incision by which this is accomplished:[48] "The arm being semiflexed, the point of the knife is entered nearly an inch below the internal condyle of the humerus, curved upward over the front of the forearm nearly to the line of the joint, and downward again to a point an inch and a half below the external condyle; the arm being then forcibly flexed, the ellipse is completed on the back of the forearm by a curved incision passing nearly three inches below the tip of the olecranon. The cuff thus marked out is rapidly dissected upward as far as necessary, when the muscles of the front of the forearm are cut about half an inch below, and the ulnar nerve as far above the joint, and disarticulation is effected from the outer side. The wound is closed transversely, forming a small curved cicatrix in front of the bone."

It is probably always advisable, except in cases of disease, to preserve the articular surface of the humerus intact, although Sir William Ferguson[49] believed that a section above the condyles leaves a preferable stump, and

one more likely to heal promptly. In all amputations at the elbow, the radial, ulnar, and interosseous arteries require ligation. When the incision through the soft parts anteriorly is made on a higher level than is ordinarily necessary, the brachial may be divided and require ligation.

Amputation of the Arm.—This may be performed at any point below the axillary folds, and all the methods of amputating may be used with advantage in different cases, since the choice of methods often permits the operator to save a considerable portion of the arm. On account of the central position of the humerus, the arm is properly considered the typical position for the double

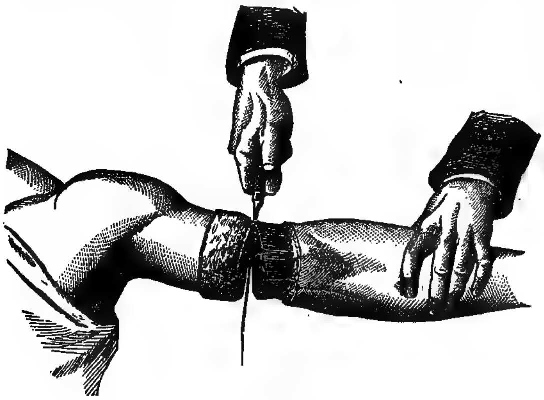

Fig. 125.

musculo-tegumentary flap operation by transfixion, and most surgeons prefer this method in this situation. The objection to be urged against it is the unequal retraction of the integument and underlying muscles, the latter generally protruding a varying distance over the cutaneous margins of the wound. Agnew properly advises that, to overcome this unequal retraction, antero-posterior oval skin-flaps should be raised of sufficient length to compensate for the difference in muscular and cutaneous retraction; after these are made, the muscular flaps are formed either by transfixion or by cutting from within outward. The latter plan of operating, although less brilliant than that by transfixion, should always be preferred in amputations of the arm in very fleshy subjects. In making

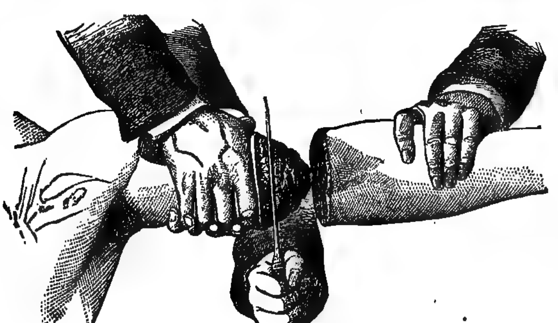

Fig. 126.

the flaps, the posterior should always be made first, the anterior, containing the important vessels and nerves, being made last. According to the dimensions of the limb, the flaps should be made from two to three inches in length.

In slender subjects, the circular operation answers admirably. In exceptionally thin arms, the integument can be retracted sufficiently to make the operation by a single circular incision. As a rule, however, it is best to formally reflect a cuff (Fig. 125), or to make rectangular cutaneous flaps by slitting the cuff on each side. In dividing the muscles by a circular incision, the biceps generally retracts more than the remaining muscles. The wound is often so irregular in consequence that a second division of the muscles becomes necessary (Fig. 126). In cases of injury attended with great destruction of the soft parts on the dorsal aspect of the arm, the Teale method, by rectangular flaps, offers particular advantages. The incisions for making the long anterior flap must be made in such a manner that the inner one shall be without the brachial artery, which should be contained in the short posterior flap.

In amputations through the middle and lower thirds of the arm, the circulation can be controlled in the ordinary manner by the Esmarch tube or tourniquet. In amputations higher up, where the tourniquet would be in the way of the operator, and liable to slip, the main artery can be compressed against the head of the bone by an assistant, or against the first rib above the clavicle. When a tourniquet is used in amputations in the upper part of the arm, it should be so applied that a roller covers the axillary artery in the arm-pit, while the plate of the tourniquet can be fixed against the acromial process of the scapula. The arteries requiring ligation after amputation of the arm are the brachial, superior or inferior profunda, occasionally the anastomotica, and four or five muscular branches. It should be remembered, likewise, that in every fifth subject, according to Quain, there is a high division of the brachial into radial and ulnar.

In 5,273 [50] cases of amputation of the arm for gunshot injury, 1,246, or 23.6 per cent., terminated fatally. The gravity of amputation of the arm does not increase with the extent of the limb removed, amputations through the lower third presenting a mortality of thirty-five per cent. against nineteen per cent. for amputations in the middle and twenty-two per cent. for those of the upper third. In the statistics of Gorman, derived from civil practice, the remarkable feature in the prognosis of amputations of the arm is even more pronounced, the mortality following amputations in the upper, middle, and lower thirds being twenty-three per cent., twenty-one per cent., and forty-four per cent. respectively. For the comparative mortality after amputations of the arm for injury and for disease the reader is referred to Table I., p. 155.

Amputation at the Shoulder.—Although this operation was referred to by ancient writers on medicine,

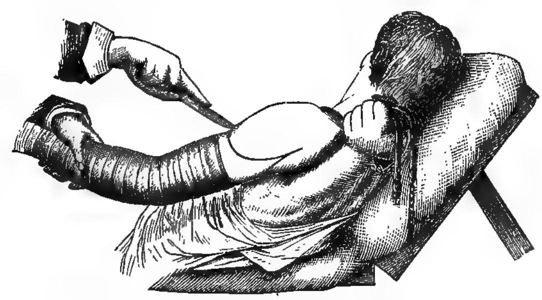

Fig. 127.

it was not performed as a formal operation till 1710, when the elder Morand performed it with a fatal result in a case of caries. The case was not recorded until some years later, by the younger Morand. The second operation, which was successful, was made in 1715 by the elder Le Dran, likewise for caries. That the arm had previously been removed at the shoulder in a case of gangrene appears in the *Jour. de Méd. de M. De la Roque*, 1686. "The surgeon took a small saw to remove the bone of the arm, but perceiving that it was loose in the joint, he gave it several slight 'jerks,' when the bone was readily drawn from the socket." [51] Ravaton, La Faye, Heister, and Bromfield repeated the operation from time to time on the continent and in England, but it remained for the distinguished Larrey to give it a firm footing among surgical procedures. Of 111 amputations made by him at this part, 97 recovered.

In all amputations of the shoulder, the circulation in the axillary artery must be controlled. While this can

be accomplished by the use of the rubber tube of the Esmarch bandage firmly wound around the axilla and shoulder, and held by an assistant or clasped toward the neck of the patient (Fig. 127) it is much better to be prepared to make compression of the subclavian artery against the first rib with a wrapped key from the moment which precedes the division of the axillary until it is firmly secured by a ligature. In all amputations of the shoulder the joint should be approached from the outer side, so that the artery is not divided until disarticulation has been effected. In this manner an assistant can pass his thumb into the wound above the knife (Fig. 128) and compress the vessel before it is cut. When such precautions as have been described can be taken, it is not necessary to make a preliminary ligation of the artery in the axilla. Amputations at the shoulder-joint can be made by the oval or flap method, and likewise by a circular operation with external longitudinal incision.

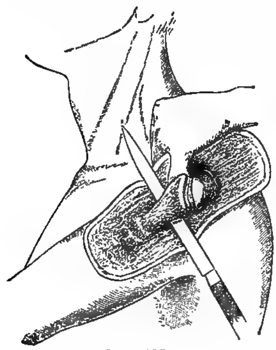

Fig. 128.

Oval Method.—This operation, generally designated Larrey's operation (as shown in Fig. 104), is performed as follows: The patient being placed in a semi-recumbent position, with the part to be amputated projecting over the edge of the operating-table, the point of the knife is introduced just beneath the point of the acromion process, and carried down over the external surface for a distance of two and one-half to four inches, according to the dimensions of the part. This incision should divide all the tissues down to the bone. From the centre of this incision an oval cut is carried around the arm, passing a little below the axillary folds, but involving only the skin and superficial fascia. The flaps thus outlined are carefully liberated from the bone. The capsule is then freely opened by a transverse cut over the head of the humerus, and the arm is rotated inward and outward to facilitate the division of the tendons of the articular muscles; in this part of the operation, the edge of the knife must be kept in close contact with the bone. As soon as the disarticulation is effected, an assistant passes his thumbs above and behind the back of the knife and compresses the axillary artery in the wound. The operation is completed by dividing the soft parts on the internal surface of the arm on a level with the cutaneous incision already made. While it is not essential, in this operation, to carry the oval incision completely around the arm before beginning the dissection of the flaps, it is preferable, since without it the lower part of the oval wound is very apt to be ragged and uneven. The wound following this operation is united so as to leave a linear cicatrix parallel to the axis of the body (Fig. 129, from a photograph of one of Ashhurst's patients).

Fig. 129.

In cases in which the humerus is shattered to such a degree that it cannot easily be used in the manipulations necessary for effecting disarticulation, the following modification of the circular incision will answer admirably. The arm being abducted, a circular incision at the lower border of, or through, the deltoid divides all the soft parts down to the bone. This, if necessary, is divided on the same level, and all the gaping vessels are ligated. When the amputation of the arm is thus completed, a long incision, dividing all the soft parts, is made from the tip of the acromion over the external surface of the shoulder to the circular wound. The remaining stump of the humerus is then seized with a strong pair of forceps, and liberated from its muscular attachments and from the joint by short incisions directed well against the bone (Esmarch).

Amputations at the shoulder by the flap method can be made either by transfixion or by cutting from without inward. The latter method, while less brilliant, is preferable in every way. It should be performed in the following manner: In amputation of the left arm the operator begins his incision at the coracoid process and carries it down over the anterior surface of the shoulder to the level of the insertion of the deltoid, across which it is carried in a wide curve; it is then prolonged upward on the posterior surface of the shoulder to the junction of the acromion with the spine of the scapula (Fig. 130). This broad flap, including a great part of the deltoid, is then raised by rapid strokes of the knife and reflected over the acromion in order that the joint may be exposed. This is made prominent by pushing the head of the humerus upward, and is to be opened by a transverse cut upon the latter. The head of the bone is now easily dislocated. The knife is then carried behind the humerus (as shown in Fig. 128) and down its inner surface to a point one or two inches below the axillary fold, when, by rapidly cutting outward, all the soft parts on the inner side are divided.

Fig. 130.

In making this operation by transfixion (Dupuytren's method) the arm must be held at a right angle with the body, while the surgeon grasps and raises the fleshy part of the shoulder with the left hand. The knife is entered one or two inches behind the acromion and pushed directly across the front of the joint, emerging just without the coracoid process of the scapula. Transfixion being effected, a broad flap is cut from within outward. The further steps of the operation are similar to those above detailed.

Both of the operations described leave a wound that, from its position, is more readily drained than that which is left by the oval method. The cicatrix which remains is transverse in direction and curvilinear.

A wound closely resembling that left by Larrey's oval operation remains after the formation of postero-external and antero-internal flaps by Lisfranc's method. In practising this method, when the left arm is to be removed, a long and narrow amputating-knife is introduced at the margin of the posterior axillary fold. The blade is then pushed along the posterior surface of the humerus until the head of the bone has been cleared, when the counter-puncture can readily be made an inch beneath the clavicle and on the outer side of the coracoid process. A broad postero-external flap must then be shaped by cutting from within outward. The capsule is then opened as in other operations, and an antero-internal flap cut likewise from within outward. In operations on the right side the posterior flap is likewise made first; the surgeon, standing behind the patient, inserts the point of

the knife from above and lets it emerge from the posterior axillary fold.

Professor Spence, of Edinburgh, has recently introduced a method of amputating which is but a modification of the oval operation, in which the perpendicular incision is made upon the head of the humerus, nearer to its inner than its outer surface. This incision is commenced just beneath and outside of the coracoid process and carried through the clavicular fibres of the pectoralis major and deltoid muscles until the humeral attachment of the former is reached. From the lower end of this incision the external and internal curvilinear incisions are almost the same as those of the oval operation as generally practised. The advantages claimed by Professor Spence[52] for this modification are the facility with which the disarticulation can be effected, the avoidance of injury to the main trunk of the posterior circumflex artery, and the better shape of the stump.

The mortality following amputation at the shoulder can be estimated from an examination of Table I., p. 155. Of 827[53] amputations of the shoulder for gun-shot fracture, in which the result was determined, 236 terminated fatally; the mortality being 28 per cent. Of 76 cases collected from American hospitals by Morton, Chadwick, and Gorman, 28 succumbed; the mortality being 37 per cent.

Amputations above the Shoulder-joint.—At least fourteen cases of avulsion of the upper extremity have been recorded in which recovery has ensued.[54] In cases of this character the integument of the stump is ordinarily so extensively lacerated and contused that insufficient tissue remains for the closure of the wound. Under these circumstances it then may become necessary to remove the whole or a greater portion of the scapula. In all cases of avulsion of the extremity, whether hæmorrhage be present or not, the main vessel must be sought and ligated. Formal amputations of the arm and part of the scapula may likewise become necessary for disease. Most of the amputations which have been made for this cause were indicated by extensive sarcomatous growths. In cases where a formal amputation of this nature is to be made, it is best to amputate the arm at the shoulder, after one of the methods already described, although the oval method or that of Lisfranc would leave a wound which could more easily be extended in a manner to make the scapula and the outer end of the clavicle accessible. Separation from the clavicle may be accomplished either with cutting-pliers or with a chain-saw. Professor Ashhurst has tabulated 51 cases of amputation above the shoulder, of which 33 recovered and 18 died, the mortality being only 25.5 per cent. It is highly probable that in the case of this, as in many other major operations, more of the successful than of the fatal cases are recorded.

Amputation of the Toes.—It is occasionally necessary to remove the toes in consequence of accident, disease, or deformity. While in cases of accident, it may occasionally be well to save a part of one of the smaller phalanges, it is generally best that the amputation be made at the metatarso-phalangeal joint. In amputations of the phalanges, a flap-operation, like that for the fingers, must be made, care being taken, as in all amputations of the foot, that the cicatrix is placed on the dorsal aspect of the stump. In amputations of an entire toe, the incision should be commenced on the dorsal surface of the metatarsal bone, a little above the joint, but considerably above the web, and carried directly down an inch or more. It is then carried obliquely around the web on each side, in such a manner as to preserve as much of the soft parts as possible. This preservation of tissue is necessary for a sufficient covering for the large head of the metatarsal bone. When performed in this manner, the cicatrix is linear and entirely removed from pressure. No part of the metatarsal bone should be removed, lest the strength of the foot be deteriorated. Disarticulation of the great toe may be effected by the oval method just described, or by the formation of an internal flap. In the latter case, an incision is begun on the outer side of the extensor tendon, just below the joint, and carried longitudinally to the head of the first phalanx. From its lower end an incision is carried transversely around the inner side, to the flexor tendon, along the outer side of which it is continued backward to the plantar fold, whence it is again given a transverse direction around the outer side of the toe until it meets the first incision near its centre (Stimson).[55] The rectangular flap thus marked out is dissected up, the tendons are divided, and disarticulation effected. Although it is sometimes recommended,[56] the head of the first metatarsal bone should never be removed unless it be implicated in the lesion, since it forms one of the most important points of support in the foot.

Amputation of all the toes at the metatarso-phalangeal joints may be made by carrying a curved incision along the groove between the base of the toes and sole of the foot from one margin of the latter to the other. The toes being forcibly flexed, a similar incision is made along the dorsum, which joins the ends of the plantar wound. The semilunar flaps thus formed are dissected back as far as the metatarso-phalangeal joints, when disarticulation of the individual toes can be made. It certainly cannot be often that a formal operation of this nature is called into requisition.

Amputation through the Metatarsus.—In consequence of injury or disease it not unfrequently becomes necessary to remove a part or all of the metatarsal bones. In amputations through individual bones of the metatarsus, conservatism must be particularly insisted upon, since, except in that of the great toe, the complete removal of a metatarsal bone cannot be accomplished without opening the large synovial sac which separates it from the first row of the tarsus. For amputations through the second, third, and fourth metatarsal bones, the longitudinal incision necessary for disarticulation at the metatarso-phalangeal joint must be carried upward for a distance varying according to the extent of bone to be removed. A short transverse incision is then made to facilitate the separation of the soft parts and the use of either chain-saw or bone-cutting forceps. When the bone has been divided, its distal end is drawn from the wound with a pair of stout forceps, and the operation is completed by severing the soft parts on its plantar surface with short strokes of the scalpel. The removal of the first and fifth metatarsal bones can be accomplished by the oval method or by internal and external flaps respectively. The oval method, where it is practicable, is doubtless preferable, since it yields a smaller wound and a cicatrix protected from pressure. The incisions for the oval amputation of the great toe with its metatarsal bone are well shown in Fig. 131. On account of the great width of the base of the latter bone, a short transverse incision facilitates the liberation of the flaps. In disarticulations of the fifth metatarsal bone the oblique line of its articulation with the cuboid bone should be borne in mind. When the first or fifth metatarsal bone is amputated in its continuity the section should be made obliquely to avoid undue prominence of the stump.

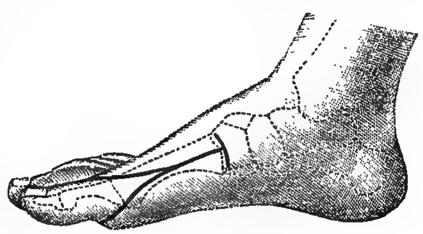

Fig. 131.

Amputation in the continuity of all the metatarsal bones is not very infrequently called for, in consequence of injury or gangrene following frost-bite. When it can be resorted to, it is preferable to amputation through the tarso-metatarsal articulation. The operation is commenced with a curved incision carried along the anterior furrow of the sole of the foot, from border to border, and the semilunar flap thus outlined is reflected to the line where section of the bones is to be made. A smaller semilunar flap is then shaped from the dorsal surface of the foot. The interosseous soft parts are then divided transversely with a narrow knife, and retracted by means of

narrow strips of linen, when the bones are sufficiently exposed for the application of the saw (Fig. 132). The appearance of the wound resulting from this operation is well shown in Fig. 133.

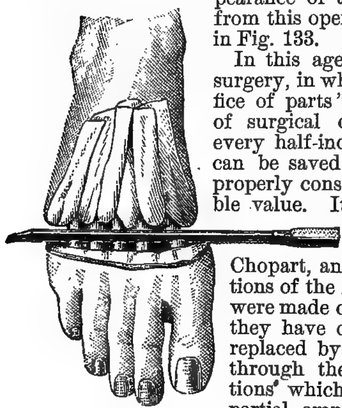

FIG. 132.

In this age of conservatism in surgery, in which "the least sacrifice of parts" is the leading tenet of surgical creed and practice, every half-inch of the foot that can be saved to the economy is properly considered of incalculable value. It is for this reason that, whereas before the times of Hey, Chopart, and Lisfranc, amputations of the foot above the ankle were made comparatively often, they have of late been largely replaced by partial amputations through the different articulations which it contains. The partial amputations which will be considered are the tarso-metatarsal, the medio-tarsal, the subastragaloid, and their modifications.

TARSO-METATARSAL AMPUTATION.—A glance at Fig. 134 shows the difficulty which the surgeon must contend with in this amputation of the foot. It is the firm impaction of the base of the second metatarsal bone between the internal and external cuneiform. In 1797, Mr. Hey, of Leeds, overcame this difficulty by disarticulating the outer metatarsal bones, and dividing the prominent internal cuneiform with a saw. Surgeons after him have generally adopted the plan of separating the outer three and internal metatarsal bones at their articulations, and dividing the base of the second metatarsal below its articulation with the middle cuneiform. When disarticulation of all the metatarsal bones is effected the operation is known as Lisfranc's (1815).

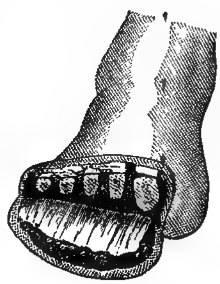

FIG. 133.

Lisfranc's amputation of the foot is made as follows: The joint between the cuboid and prominent base of the fifth metatarsal bone having been marked on the outer side of the foot, and that between the first metatarsal and

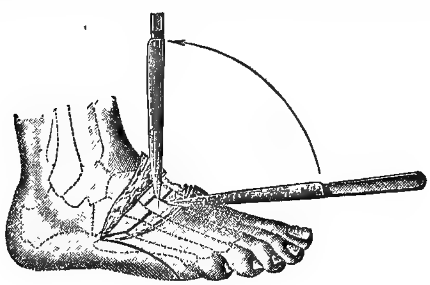

FIG. 134.

internal cuneiform (about one inch and a half below the tuberosity of the scaphoid) on the inner side, a large semilunar incision is made between them on the sole of the foot, the convexity of which should pass over the heads of the metatarsal bones. The plantar flap thus outlined may then be dissected up to its base. The foot being then forcibly extended, a slightly convex dorsal incision is carried between the ends of the plantar flap (Fig. 135). The flaps being retracted and the foot forcibly extended, the operator opens the joint from the outer or inner side, according to whether the right or the left foot be the seat of the operation (Fig. 136). The articulation of the second metatarsal bone (Fig. 137, *b*), which is less than half an inch above the general level of the joints, must then be opened by a transverse cut, the lateral attachments of the bone to the cuneiform being severed with the point of the knife by longitudinal incisions (Fig. 134). When all the joints are widely opened by this process, the remaining ligaments at the side and sole of the foot, and the soft parts still undivided, are severed. As the operation is generally performed, the plantar flap is merely outlined by an incision through the skin in the first step of the operation, the flap being cut from within outward after disarticulation has been effected. The vessels usually requiring ligation are the dorsal artery of the great toe, the metatarsal branches, and the plantar arteries. When the parts are brought together by suture, the stump should be placed in a posterior splint, to overcome the contraction of the powerful muscles of the calf of the leg. In Hey's amputation, the external incisions are identical with those necessary for the Lisfranc operation. The cicatrix resulting from either of these proced-

FIG. 135.

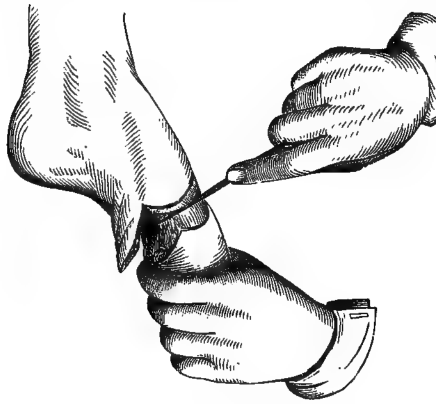

FIG. 136.

ures is far removed from pressure, and the stump, on account of its length, one admirably fitted for use.

MEDIO-TARSAL AMPUTATION. — Although Garengeot and Heister mentioned the practicability of amputation between the rows of the tarsal bones, the operation was first performed by du Vivier, of Rochefort, in 1781.[57] In 1791 Chopart repeated the operation a number of times, and published his experience with it. It has since been known as "Chopart's amputation," and the joint between the rows of the tarsus is not infrequently designated by his name. Although it was opposed by Larrey, who preferred to amputate in the lower part of the leg, the operation was popularized by Roux and Walther on the continent, and by Mr. James, of Exeter, and Syme, in Great Britain.

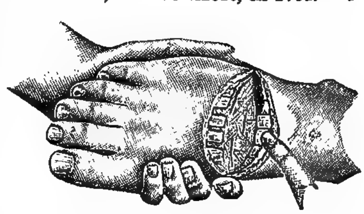

FIG. 137.

The articulation between the scaphoid and the head of the astragalus, and that between the cuboid and os calcis are respectively placed one-half inch above the tuberosity of the scaphoid on the inner border, and one inch or more above the prominence of the fifth metatarsal bone upon

the outer border of the foot. These two points being fixed, a curved incision, extending to within an inch or less of the heads of the metatarsal bones, is carried across the sole of the foot, and connects them. The foot being then forcibly extended, a curvilinear incision, with convexity below, is carried between the same points across the dorsal surface. The small dorsal cutaneous flap thus outlined is retracted, and by one stroke of the knife the tendons are divided and the joint widely opened. The point of the knife then divides the lateral and plantar ligaments, which are put on the stretch by forcible extension until the articular surfaces of the scaphoid and cuboid bones are completely liberated. By inserting the knife

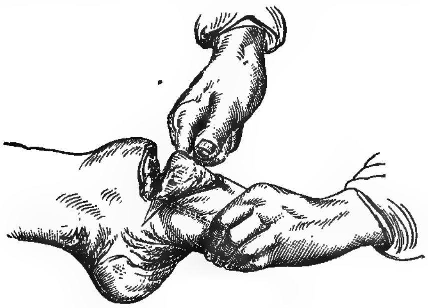

FIG. 138.

behind these bones, the plantar flap is completed by cutting from within outward (Fig. 138). The vessels requiring ligation are the dorsal and two plantar arteries, and occasionally a few muscular twigs. The appearance of the stump after the completion of Chopart's amputation is well shown in Fig. 139, from Esmarch.

The only difficulty at times encountered in this operation is in the opening of the joint *in front* instead of *behind* the scaphoid bone. The error is readily recognized through the presence of three articular facets on the anterior surface of the scaphoid bone, and can easily be corrected if it be desired, or the operation may be completed by dividing the cuboid bone with a saw on a line with the anterior surface of the scaphoid. In this manner the operator would be practising Forbes's[58] modification of the medio-tarsal amputation, a modification also mentioned by Mr. Hancock and Professor Agnew.

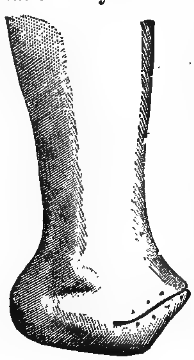

FIG. 139.

After Chopart's amputation, the gastrocnemius and soleus having exclusive control of the stump, there is a marked tendency toward its hyperextension. This may assume such a degree that the cicatrix itself will be pressed upon in locomotion. This objection to the operation is best overcome by bandaging the leg from above downward, and keeping the limb flexed. In extreme cases the difficulty is easily remedied by division of the tendo Achillis, and forced flexion of the stump.

SUBASTRAGALOID AMPUTATION. — Although, according to Velpeau, this operation was made by de Lignerolles and by Textor, it was first given prominence by Malgaigne, in 1846. In this amputation all the bones of the foot, except the astragalus, are removed. The operation is commenced by an incision, which, beginning behind and immediately above the great tuberosity of the os calcis, at once divides

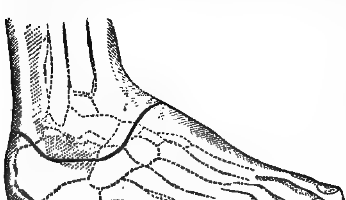

FIG. 140.

the tendo Achillis. The incision is then carried in a wide curve on the outer surface of the os calcis below the external malleolus (Fig. 140, Malgaigne). Thence it is continued over the middle of the cuboid and anterior margin of the scaphoid, across the dorsum of the foot (Fig. 141), and over its internal border to the centre of the sole (Figs. 142 and 143). From this point the incision is turned at a right angle and continued directly back till it meets the beginning of the incision at the inner border of the tendo Achillis (Esmarch). The short internal and long interno-plantar flaps thus formed are dissected up until the lateral surfaces of the os calcis are exposed, when disarticulation of the anterior part of the foot is effected in the medio-tarsal joint. The anterior end of the os calcis being then seized with a lion-jawed forceps, and rotated from side to side, the operation is completed by dividing the external lateral and interosseous ligaments. The appearance of the stump after this operation is shown in Fig. 144 (Esmarch). The marked irregularities of the inferior surface of the astragalus do not interfere with its usefulness in locomotion. In a case of gangrene in a deformed limb, Linhart performed the subastragaloid amputation, and was enabled two years later to examine the stump. The astragalus, which had maintained a perpendicular position before, and even at the time of amputation, had been forced into its normal horizontal position by the act of walking.[59]

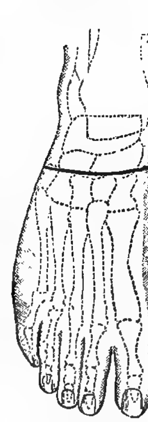

FIG. 141.

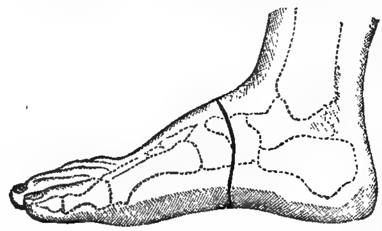

FIG. 142.

A number of modifications of the subastragaloid amputations, both in the direction of the incisions and in the preservation of parts of the os calcis, have been devised. In the operation of Mr. Hancock, a large plantar flap is reflected as far back as the tuberosities of the calcaneum, and a short dorsal flap is formed by a transverse incision across the foot on a level with the anterior margin of the astragalus. By the use of a saw, the plantar flap being retracted, a perpendicular section of the os calcis is then made in front of the tuberosities. Disarticulation of the foot, with the anterior portion of the os calcis, in the medio-tarsal joint is next effected, and the operation completed by making a transverse section of the astragalus. When the flaps are approximated the divided surfaces of the latter bone and os calcis are brought into apposition. The operation of Mr. Hancock, although as ingenious as that of Pirogoff, is much more difficult of execution, and time will probably show that the results obtained from it are far less valuable. In Tripier's operation the incision is made in the form of an oval, the apex of which is on the outer side of the foot, just beneath the external malleolus, while the sides pass forward and inward over the back and sole of the foot, and

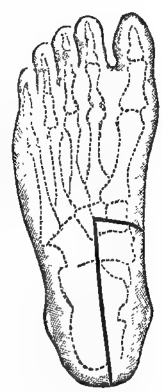

FIG. 143.

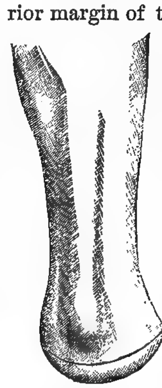

FIG. 144.

meet at its inner border. After disarticulation in the medio-tarsal joint, a transverse section of the os calcis completes the operation.

Partial amputations of the foot, at least in civil practice, are not attended with great mortality. Of 152 cases of Chopart's amputation, examined by Hancock, only 11 terminated fatally, seven per cent. ; the fatality following this operation in France has been much greater, 14 out of 38 cases recorded by Larger (36.8 per cent.) having died (Ashhurst). Of 22 cases of the subastragaloid amputation 20 recovered.

Of 123 partial amputations of the foot, made during the late Rebellion, in which the result was determined, 18 were unsuccessful, the mortality being fifteen per cent. Of these partial amputations there were 83 of the medio-tarsals, with 11 deaths; 23 Lisfranc operations with 1 death, and 17 Hey's amputations with 6 deaths.[60]

Amputation at the Ankle.—Historically associated with this operation is the name of Syme, of Edinburgh, who, in 1842, devised and practised a method by which a shapely and useful stump could be obtained after removal of the entire foot. Disarticulation at the ankle had been performed during the last and early part of this century. It was performed by Sédillier, Rossi, and Baudens, and recommended by Brasdor and Sabatier. But the circular operation of the latter and the dorsal flap method of Baudens yielded alike unsatisfactory results, and the operation was, therefore, discarded for amputation in the lower part of the leg. Lateral flaps taken from below the malleoli, as suggested by Velpeau, also failed to form a sufficient cushion for the end of the tibia. This great desideratum in amputation at the ankle is squarely met by the operation of Syme,[61] since its principal feature is the retention of the integument of the heel, which is accustomed to pressure, to form the end of the stump. The operation is made in the following manner: The foot being held at a right angle to the body, the malleoli are fixed by the thumb and fingers of the left hand, the heel resting between them. A *perpendicular* incision touching the bone is then made across the sole of the foot from the tip of one malleolus to that of the other * (Fig. 145). The posterior lip of the wound is then seized with the left hand, and the soft parts covering the calcaneum are separated from it by short strokes of the knife, which must be kept close against the bone to prevent perforation of the integument and damage to the plantar vessels. When, by this process of dissection, the tuberosities of the os calcis have been fairly exposed, a transverse incision joining the two extremities of the first is carried across the instep (Fig. 145). The ankle-joint being thus opened from in front, the knife is carried down on each side of the astragalus until the lateral ligaments are divided, when complete disarticulation is effected. By forcibly depressing the foot the tendo Achillis should then be divided from before backward, when by a few strokes of the knife the foot can be removed (Fig. 146, Esmarch). Lastly, the knife is drawn around the extremities of the tibia and fibula, so as to expose them sufficiently for being grasped in the hand and removed by the saw. "After the vessels have been tied, and before the edges of the wound are stitched together, an opening should be made through the posterior part of the flap where it is thinnest, to afford a dependent drain for the matter."

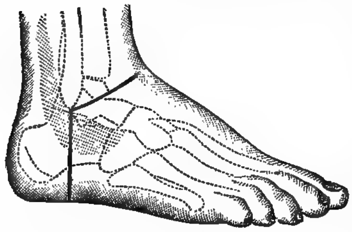

Fig. 145.

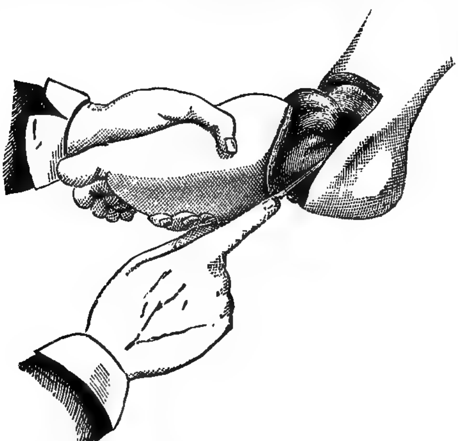

Fig. 146.

Fig. 147.

The appearance of the wound after Syme's amputation is well shown in Fig. 147. It will be seen that the heel flap presents the form of a cup, which must be flattened by pressure against the bones of the leg. While there is danger, therefore, of making the flap too short, there is likewise a danger in making it too long, since a pouch would be formed for the retention of inflammatory products.

The favorable results which follow Syme's amputation in civil practice are shown by the statistics of Hancock and Spence, who, among 316 operations, found only 25 deaths (7 per cent.). In military practice the results are far less favorable. Of 159 amputations made at the ankle during the civil war,[62] and in which the result was determined, 40 terminated fatally (25.1 per cent.).

Pirogoff's Amputation.—On the principle that by preserving the posterior portion of the calcaneum the natural length of the limb could almost be preserved, Pirogoff, during the Crimean war, devised the osteoplastic operation that bears his name. It differs from the operation of Syme in preserving a portion of the os calcis, in the expectation that it will unite firmly to the divided end of the tibia. The incisions for this amputation are identical with those made in Syme's operation. After opening the joint from in front, the foot is depressed until the posterior extremity of the astragalus is exposed,

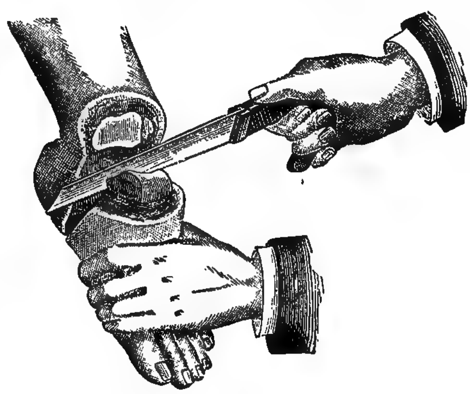

Fig. 148.

* Recent writers justly observe that the incision on the inner side should end at least one-half inch *below* the malleolus.

when a saw is introduced behind this and the os calcis divided exactly on a level with the incision in the sole of the foot (Figs. 148 and 149, Esmarch). Both malleoli and a thin section of the tibia and fibula are removed, as in Syme's operation. It is generally advisable to divide the tendo Achillis and at the same time to perforate the skin for the passage of a drainage-tube. The appearance of the stump after a successful Pirogoff amputation is well shown in Fig. 150, taken from a man who died three years after the operation was made by Linhart.[63] A number of modifications of Pirogoff's amputation have been devised. Ferguson and Agnew have wedged the end of the os calcis into the interval between the malleoli, and obtained good results. Different methods of dividing the bone have been devised by Sédil-

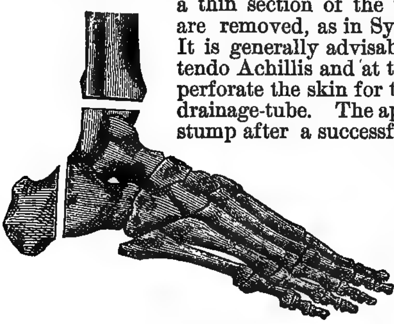

FIG. 149.

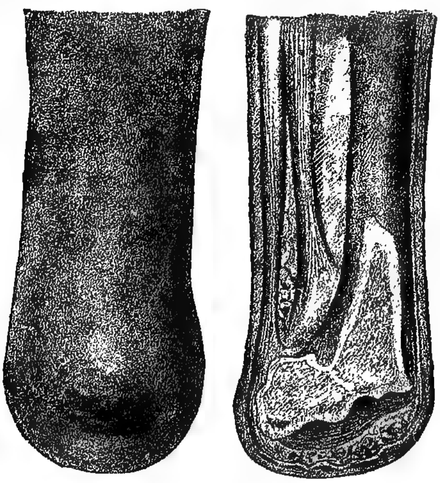

FIG. 150.

lot, Günther, Le Fort, and Bruns, to remove the pressure from the thin part of the integument on the back of the heel, which must bear it after the Pirogoff amputation, and to keep the retained part of the os calcis in its natural position. Sédillot and Günther, therefore, advised that an oblique section (from above downward and forward) of the calcaneum, tibia, and fibula be made. Le Fort (Fig. 151) advised a transverse section of the bone, by which the stump obtains a very broad base. Bruns has modified the operation of Le Fort by sawing the os calcis in such a manner as to make the upper surface of the retained part concave, the concavity thus formed receiving the convex section of the tibia and fibula.

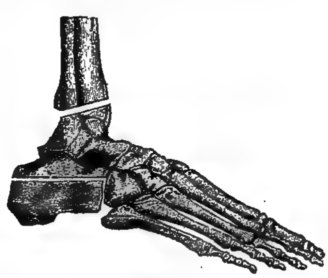

FIG. 151.

A comparison of the merits of Syme's amputation and its osteoplastic modification shows that a cure follows more rapidly after the latter than the former, although the mortality of Pirogoff's amputation in military practice is 27.7 per cent. against 21.4 per cent. following that of Syme. Of 147 cases of Pirogoff's amputation collected by Hancock, Gross, and Pasquier, only 14 proved fatal, and Volkmann has performed the operation thirty-four times without a death. Considering the number of reamputations after Syme's and Pirogoff's operations, the latter would seem to be the more successful. Of 83 cases of Syme's amputation, 20, or 24 per cent., submitted to reamputation; of 49 Pirogoff's operations, 8, or 16.3 per cent., were subjected to reamputation.[64]

In cases of caries involving all the bones of the tarsus, preference should be given to the Syme operation, since disease is not unlikely to develop in the retained segment of the calcaneum. In traumatic cases, the greater ease with which it is made and the length of limb which follows it should incline the operator to choose the operation of Pirogoff. That necrosis often follows the latter operation is emphatically denied by its originator, who had never witnessed it in over 60 cases in which he had performed it.[65]

AMPUTATION OF THE LEG.— An amputation may be performed in any part of the leg according to the nature and seat of disease or injury. When the surgeon can select the seat of operation, the amputation should be made two or three inches above the malleoli, on account of the greater safety of the operation in this locality and the greater power to be exerted over an artificial limb. The operations which have hitherto been most frequently performed in amputations above the malleoli, are the circular and that by lateral flaps. Unhappily, the anatomical construction of the part is such that after these operations the cicatrices are central and not infrequently adherent, and therefore unable to bear pressure. In this situation M. Guyon[66] practises the elliptical method.

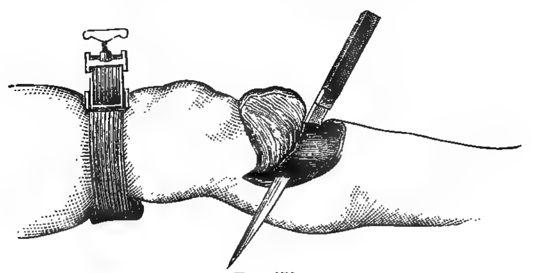

FIG. 152.

According to Stimson,[67] this operation promises well. "The incision is made in the form of an ellipse, whose lower end crosses the heel below the insertion of the tendo Achillis, and whose upper end is about an inch above the anterior articular edge of the tibia. Beginning at the lower end and dividing the tendo Achillis at its insertion, and hugging the bone all the way, the flap is dissected up posteriorly as high as the upper end of the ellipse. The anterior muscles are then divided by transfixion, the bones sawn through, and the posterior tibial nerve resected. In this operation the sheath of the tendo Achillis is not opened, and the tendon itself serves afterward as a covering for the ends of the bones."

In amputations in the lower third of the leg in fleshy subjects, a long anterior flap containing the interosseous muscles may sometimes be used with advantage (Bell). The rectangular operation of Teale may likewise be practised in this region, the long anterior flap being made from the soft part of its anterior aspect (Fig. 109, see above, Methods of Amputation). By this method the cicatrix, being placed posteriorly, is out of the way of pressure.

In the middle and upper thirds of the leg very many operators amputate by means of antero-posterior flaps after the following manner (for the left limb): The point of the knife being entered at the posterior edge of the tibia, an incision is carried downwards along this for an inch and a half to two inches, then by a wide curve across the anterior surface of the leg it is continued to the posterior border of the fibula up which it is carried until the level of its commencement on the opposite side is reached. The broad flap thus outlined is rapidly dissected up, the interosseous muscles being carefully severed

from the underlying membrane. The posterior flap is then made by transfixion and cutting from within outward, and should be about three inches long (Fig. 152, Erichsen). The flaps being held out of the way, the catling is to be used for completing the division of the interosseous soft parts, care being taken that the arteries be divided transversely and only once. After division of the bones with a saw, the sharp anterior edge of the tibia should be removed obliquely with the saw or bone-cutting forceps.

For the upper portions of the leg the long posterior rectangular flap amputation advised by Henry Lee [68] gives an excellent result. The incisions, similar to those of Teale, involve only the skin, the long flap being made from the posterior, the short one from the anterior surface of the limb. With the long posterior flap only the superficial muscles of the calf are reflected, the remaining soft parts being divided by a circular incision. A good covering is likewise obtained in this region by an external flap, made either by transfixion (Sédillot), or by cutting from without inward (Langenbeck). In the former operation the knife is entered a little external to the crest of the tibia, and while the soft parts are drawn to the outer side with the left hand, it is made to graze the surface of the fibula and to perforate the posterior surface of the limb as far to the inner side of the fibula as possible. By cutting downward, close to the bones, a broad rounded flap, three to four inches long, is formed. The extremities of this flap are then united by a slightly convex incision across the antero-internal aspect of the limb. The remaining soft parts being then divided by circular incision, the operation is completed in the ordinary way. In Langenbeck's operation, the internal incision is semicircular, and the external flap being cut from without presents a smoother surface and a more perfect outline. The arteries requiring ligation after amputation of the leg are the tibials, peroneal, and a varying number of muscular branches.

Since good results follow all the different methods of operation in the middle and upper portions of the leg, the surgeon should be guided in his choice solely by the desire to sacrifice as little of the limb as possible. An exception should probably be made in the upper portion of the upper third, where it is better to amputate at the knee than to save only the portion of the tibia above its tubercle.

The mortality following amputation of the leg, as has already been seen, is largely determined by the conditions necessitating it. According to Chadwick, the mortality of pathological amputations is 16 per cent. ; that of amputations for trauma nearly 37· per cent. The general mortality of the operation at Guy's Hospital for a period of thirty years was 35 per cent. ; that for traumatic amputations being 55 per cent. against 15 per cent. following those for disease. Volkmann, who employs a long anterior and short posterior flap, performed the operation in 54 cases with only 4 deaths (7 per cent.), of which there were 14 traumatic cases with only 2 deaths (14 per cent.). Of 46 amputations in the leg made by Bruns, 7 succumbed (16 per cent.). The fatality following amputations of the leg in military practice is well shown by the statistics of Otis. Of 5,314 amputations [69] in which the result was determined, 1,753 terminated fatally, the mortality being 32.9 per cent. From statistics obtained during the late War of the Rebellion, it appears that amputation of the leg is attended with least danger when performed in the middle third. The fatality of operations in the upper third was 27 per cent., in the middle third, 20.6 per cent., and in the lower third, 27.6 per cent.

Amputation at the Knee.—According to Sabatier,[70] this operation was first performed by Fabricius Hildanus in 1581, in a case of gunshot injury. Although advocated by Guillemeau (1612) in preference to higher amputation, there is no record of a repetition of the operation until 1764, when it was successfully performed by Hoin, of Dijon, for traumatic gangrene. Brasdor and J. Le Petit advised the operation, the latter having twice witnessed it. In 1830, Velpeau attempted with success to firmly establish the operation by citing a number of successful cases. The operation was first performed in this country by Nathan Smith, of New Haven, in 1824, since which time it has gradually grown in popularity. Fergusson and Legouest for a long time questioned the advisability of the operation, preferring amputation in the lower portion of the thigh. The reasons which prevailed to give this operation recognition are the greater length of the stump and its ability to bear pressure, the smaller probability of pyæmia, the medullary canal remaining unopened, and, most important of all, the smaller mortality which follows this operation, at least in civil practice, as compared with amputations of the thigh.

Amputation at the knee may be practised by either the circular, flap, or oval method. The circular operation recommended by Velpeau, Sanson, and Malgaigne, made by an incision two or three inches below the patella and the reflection of a cuff, is difficult of execution, and should be resorted to only when an insufficience of tissue prevents the adoption of one of the other methods. The oval method has been practised by Baudens and Sédillot, the former preferring the integument from the anterior portion of the leg, the latter that from the posterior portion as a covering for the end of the femur. The operation of Baudens is performed as follows: An oval incision is carried around the leg, crossing its anterior surface five finger-breadths below the end of the patella, and its posterior surface three finger-breadths higher than in front. The anterior and lateral portions of the oval are then reflected until the ligamentum patellæ is fairly exposed. This is then divided transversely, the capsule is fairly opened, and the lateral and crucial ligaments divided. In this, as in all amputations of the knee, the latter structures should be divided with the point of the knife, and from behind forward to prevent injury of the

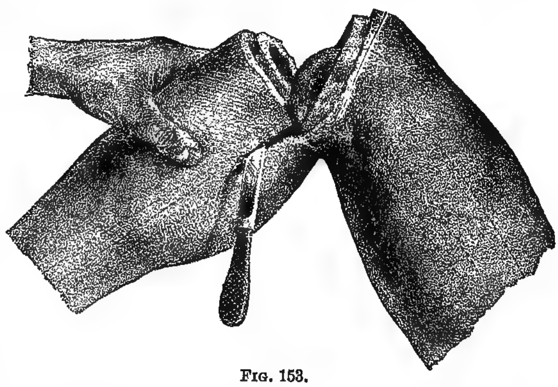

Fig. 153.

popliteal vessels. When disarticulation has been effected, the soft parts on the posterior aspect of the limb are divided with one sweep of the knife. This operation is, doubtless, preferable to Sédillot's method, according to which the lower part of the oval is placed behind.

In amputating at the knee, a long flap may be taken from the anterior or posterior surface of the leg. The latter method, that of Hoin (Fig. 153), can be most readily executed, but is objectionable on account of the excess of muscular tissue in the flap, and the difficulty of establishing thorough drainage. Lateral flaps have been advised by Rossi and Stephen Smith. The operation which is generally performed, however, is that by one long anterior and one short posterior flap. It is readily performed, leaves a wound that is easily drained, and a stump in which the cicatrix is protected from pressure.

Operation.—The leg being raised, a semilunar flap, three to four inches long, is outlined from the calf, the incision beginning a little below the middle of the lateral border of the condyles. This flap is dissected up as far as its base. The leg being then flexed, an anterior flap, four to five inches long, is outlined on the anterior surface of the leg from the ends of the posterior incision (Fig. 154, Esmarch). The anterior flap is then raised from its attachments until the ligamentum patellæ is en-

countered and transversely divided. The capsule is then extensively incised laterally, and the anterior flap, including the patella, reflected (Fig. 155). Disarticulation and division of the soft parts on the posterior aspect of the limb are then effected in the manner already described. This operation is preferable to forming the posterior flap without the guidance of a cutaneous incision. The vessels requiring ligation are the popliteal artery and vein, which should be carefully separated and tied individually.

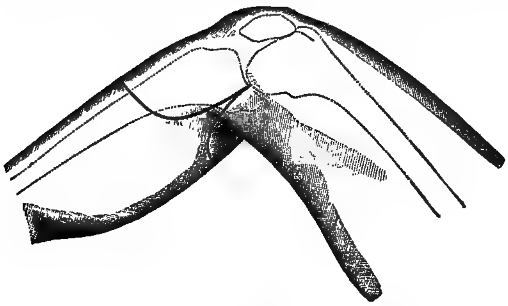

FIG. 154.

A number of smaller arteries, sural and muscular, will also require ligation in the posterior portion of the wound.

A number of operators (Billroth among them) advise the removal of the patella, lest inflammatory products accumulate in the pouch above it. This procedure is generally held to be superfluous, since the upper part of the wound can readily be drained without it, and the removal of the patella endangers the vitality of the long flap. It is always advisable, to insure drainage, to divide the lateral attachments of the synovial membrane to the femoral condyles, by which means the retention of inflammatory products in the pouch alluded to can be avoided.

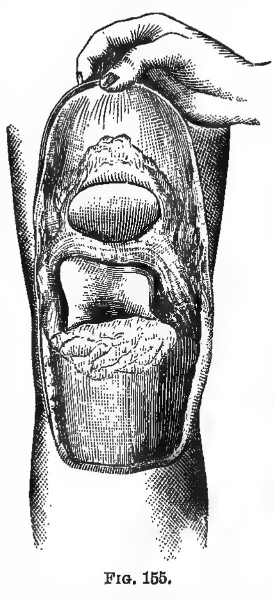

FIG. 155.

In the last forty years a number of modifications of the operations just described have been introduced. They all have the feature in common that a portion of, or the entire condyles of the femur are to be removed. In 1845 Syme advised amputation through the condyles, making a large posterior musculo-tegumentary flap. In 1846 Mr. Carden [71] first performed the operation which has since borne his name, and has become deservedly popular. The operation consists in the formation of a long anterior flap, which, like a hood, falls easily over the divided end of the bone. The incision, similar to that made for amputation at the knee, extends no farther down than the tubercle of the tibia. The anterior flap being reflected, the joint is opened *above* the patella, which is not included in the flap. After disarticulation has been effected, the soft parts of the posterior [72] aspect of the limb are severed by a single stroke of the knife, and the saw is applied through the bases of the condyles. For the better coaptation of the cutaneous margins of the wound Lister has advised the formation of a short posterior tegumentary flap. Mr. Carden has recorded 30 operations, with only five deaths from this method. Of 26 Carden amputations made by Volkman, 3 terminated fatally.

In 1857, Gritti, of Milan, devised an osteo-plastic operation by which the articular surface of the patella is removed, and placed in apposition with the divided ends of the femoral condyles. The operation was first practised by Sawostytzki in 1862.[73] In this operation, long anterior and short posterior rectangular flaps are formed. Paikrt and Linhart [74] after raising the anterior flap, amputate without first disarticulating. In 1870 Dr. Wm. Stokes [75] still further modified Gritti's operation by making an oval flap and dividing the femur at least half an inch above the antero-superior margin of the condyloid cartilage. Hence this amputation is generally known as the *supra-condyloid* amputation, that of Carden being known as the *trans-condyloid* operation. The relative merits of these various methods of amputation at the knee have been extensively investigated by American, English, and German writers. Edmund Andrews,[76] of Chicago, shows that disarticulation at the knee and trans-condyloid amputation present a like mortality (28 per cent.). Of Gritti's operation and Stokes's modification, Dr. R. F. Weir [77] has collected 76 cases with 22 deaths. While time may show that the last-mentioned procedures may be of service in amputations for disease, sufficient evidence has been adduced by Zeiss,[78] Beck,[79] and Salzman,[80] that, so far as military practice is concerned, the operation ought to be abandoned.

The mortality of amputations at the knee in civil practice appears from an examination of Table I. (see above). Of 187 amputations made for gunshot injury, in which the result was determined, 106 succumbed, the mortality being 56.6 per cent., and exceeding by 2.8 per cent. the fatality of amputations in the lower part of the femur.[81]

AMPUTATION OF THE THIGH.—This operation may be called for in any part of the thigh. The central position

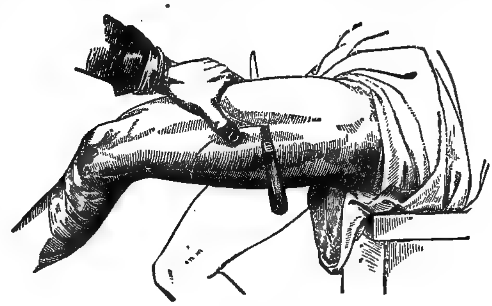

FIG. 156.

of the femur, and its extensive muscular covering, sanction the application of any of the various methods of amputation in this part. The choice from among the different operations permits the surgeon at all times to save as much of the femur as possible. It has been found, however, that the method with anterior and posterior flaps is generally attended by better results, and is more readily executed than other operations. The manner in which it is generally performed is the following: Grasping and raising the soft parts on the anterior aspect of the limb with his left hand, the operator introduces the knife at the side of the limb, at a point an inch or more below the level of the proposed section of the femur, and, carrying it across the anterior surface of the femur, transfixes and cuts out a broad flap equal in length to half the diameter of the limb (Fig. 156, Fergusson). The flap thus formed being retracted, the knife is again introduced into the wound behind the femur, and a posterior flap formed by cutting from within outward and downward through the soft parts. The flap thus made should be quite as long as the anterior, since the greater retraction of the posterior muscles would otherwise reduce it to a size that would prevent the accurate coaptation of the cutaneous margins of the wound. In very fleshy subjects, all of the muscular tissue should not be included in the flaps thus made. When the flaps have been made they are retracted by an assistant, the bone is cleared of the still adherent soft parts by a circular sweep of the knife at the level where the saw is to be applied. In amputating by musculo-tegumentary flaps below the middle of the thigh,

the anterior flap should be formed first; in amputations higher up it must be made last, in order that the femoral vessels may not be divided until the operation has been nearly completed. The vessels requiring ligation in amputations below the middle of the thigh are the femoral, anastomotic, and five or six muscular branches.

Amputation of the thigh by lateral musculo-tegumentary flaps, as recommended by Vermale, should not be resorted to, since, owing to the weight of the soft parts, the flaps are easily displaced, and the end of the bone is liable to protrude from the upper angle of the wound.

In the middle and upper portions of the thigh the very best results are unquestionably to be obtained by the modified circular method, the cutaneous flaps being made in front and behind, and the muscles divided by a circular incision. The admirable results which Volkmann and Bruns achieved from amputations of the thigh are largely attributable to their preference for this method. With a longer anterior and shorter posterior cutaneous flap, the wound obtains an excellent position for drainage (Fig. 157, Hueter), and the stump which is left is well suited for the application of an artificial limb. In the lower third of the thigh the operation may be made with only a single long anterior flap, which should extend as low as the upper margin of the patella, the integument on the posterior aspect of the limb being divided by a semicircular incision. The latter should be made at least half an inch below the ends of the margins of the anterior flap; to allow for the greater retraction of the posterior lip of the wound (Fig. 158). In amputations near the hip or through the trochanters, no other operation than that by long anterior and short posterior flaps leaves a wound that is easily drained. When there is any question as to the vitality of the long anterior flap, it is an easy matter to include with it a varying thickness of the muscular tissue.

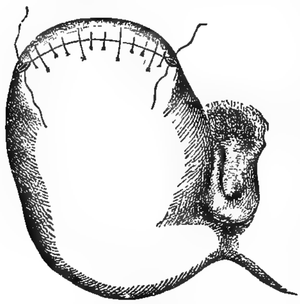

FIG. 157.

A study of Table I. shows that amputations of the thigh are associated with a mortality that is largely responsible for the high death-rate attending major amputations in general. The fatality of this operation in civil practice increases as the trunk is approached.

According to Macleod and Legouest, this applies equally to amputations for gunshot injury.

According to the statistics of Otis,[82] this view, which is generally entertained, must be modified. Of 768 amputations for gunshot injury, made in the upper third of the thigh, 53.8 per cent. died. Of the 1,866 amputations made in the middle third, 44.5 per cent. died. Of 2,901 operations in the lower third, 53.6 per cent. succumbed.

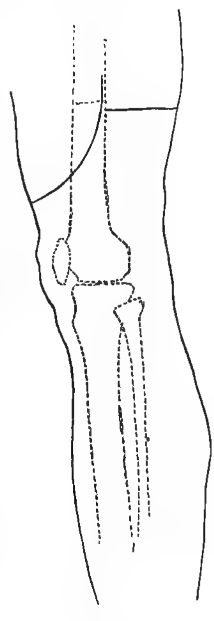

FIG. 158.

The general mortality attending the operation is represented by 6,229 cases, with 3,310 deaths, the mortality being 53.8 per cent.

AMPUTATION AT THE HIP.—The first idea of this operation, the most formidable of justifiable surgical procedures, appears to have originated with Morand and two of his pupils, Volker and Puthod, who practised it on the cadaver in 1738. A year later, Le Dran taught the operation in his practical courses, and presented a report on its feasibility to the French Academy. In 1840 Ravaton proposed to amputate at the hip-joint on a patient, but was dissuaded therefrom by other surgeons in consultation. In 1756 and 1759 the Parisian Academy offered a prize for the best treatise on the justifiability of the operation and the best method of performing it. Of forty-four contestants, thirty-four supported the operation, the prize being awarded to Barbette, who concisely mentioned the indications that made it necessary. That life could continue after loss of the lower extremities had been shown by the following case: "In 1748, there came to the hospital of Orleans, a lad fourteen years of age, who was the subject of ergotism. Gangrene of both lower extremities had supervened, extending on the right side to the hip-joint, and on the left to the trochanter. The suppuration which was established almost separated the right thigh, the round ligament and great sciatic nerve alone holding it to the trunk. Lacroix, surgeon to the hospital, completed the separation of the member. This operation succeeded so well, that four days later he also amputated the left thigh. There was neither hæmorrhage nor pain, and the patient progressed well till the tenth day, when fever supervened, and death followed fifteen days after the first operation."[83] In 1773 Perault removed the entire thigh in a case of traumatic gangrene "of several months' duration," in which a complete recovery ensued in eighteen months.

Although in 1774 and 1778 Kerr and Thomson made the first amputations at the hip through living tissues in cases of coxalgia, both operations terminated fatally, and the procedure was not again resorted to till the last decade of the past century. Amputation at the hip in reality owes its existence to the wars of the French Revolution. In 1794 the elder Blandin performed it thrice, with one recovery. During his different campaigns, Larrey repeated the operation seven times and gave it a standing among surgical procedures, although it is doubtful whether any of his cases recovered.[84] In 1812 and 1815, Brownrigg and Guthrie, after repeated failures, were enabled to report successful amputations at the hip for gunshot injury. The first operation in this country was made in Kentucky in 1806, by Brashear, for compound fracture, and ended in recovery.

The most comprehensive statistics of the operation in question have been collected by Otis,[85] Lüning,[86] and Ashhurst.[87] Over three-fourths of all the operations have been made since the introduction of anæsthesia, and fully two-thirds of the entire number were performed later than 1860. Up to 1875 Lüning was enabled to collect but 497 well authenticated cases, while in 1881, Ashhurst was enabled to tabulate 633 operations, since which time over a hundred cases have been added to the list.

The question of supreme moment in amputation at the hip-joint, is that which pertains to a complete, and yet safe method of controlling the circulation during the operation. Its importance becomes manifest from the fact that five per cent. of the patients operated on do not survive the operation, and that seventy per cent. of the deaths occur during the first five days (Lüning). To overcome this great and immediate danger of amputations at the hip, progress has been made in the direction of preserving the blood contained in the condemned part and by temporarily or permanently occluding the sources of its blood-supply. By the use of the elastic bandage from the toes to the groin, and keeping it in place during the operation (Erskine Mason), or in cases of extensive suppuration of the extremity, by maintaining the latter in a vertical position for some minutes before the operation, a not inconsiderable amount of blood can be saved to the economy.

Preliminary ligation of the femoral or external iliac artery is, as a rule, unnecessary, and has been generally abandoned since it has been ascertained that secondary hæmorrhage is more apt to follow the ligation of an artery

in its continuity than at its cut extremity in a wound. In exceptional cases, however, where skilful assistants are not at hand, or where a neoplasm extends quite up to the pelvis, preliminary ligation may still be resorted to with advantage. An interesting case of the latter nature has recently been recorded by Trendelenburg, in which the external iliac was ligated, the patient making a good recovery.[88]

In 1860 Professor Pancoast first called attention to the practicability of compressing the aorta against the vertebral column by means of an abdominal tourniquet. A number of instruments have since been devised similar to that of Pancoast, by Lister, Skey, and Esmarch, and it is to one of these contrivances that most surgeons have recourse before proceeding to the operation proper. In the tourniquet of Esmarch the aortic pad exerts its compression by means of an elastic band which is passed through its handle. In the absence of a tourniquet, a pad can be improvised by firmly winding a long roller bandage around the middle of a stick, which should be about a foot long, and of the thickness of the thumb. The pad thus formed being placed in position, is retained by five or six turns of an elastic bandage around the abdomen (Esmarch). Professor Spence resorts to a similar procedure. Whatever tourniquet be used, it should be applied while the patient is lying on the right side, the pad being placed a little to the left of the umbilicus (Fig. 159, Esmarch). The operation should not be commenced until the operator has satisfied himself that the circulation in the lower extremities is completely controlled.

FIG. 159.

It having been held, but without sufficient clinical evidence, that prolonged compression of the abdominal aorta is injurious from damage to the branches of the solar plexus, and by interfering with respiration, compression of the common iliac artery through the rectum has been advised and practised. Woodbury, of Philadelphia, and Van Buren, of New York, proposed that this be accomplished by the hand of an assistant, while R. Davy,[89] of London, devised for the same purpose a polished rod twenty inches long, and from half to three-fourths of an inch thick, surmounted at its extremity by an ivory enlargement, with which the artery is to be compressed against the brim of the pelvis. In one case in which Davy used the lever on the right iliac artery, death followed from a rent in the rectum. In seventeen other cases in which he had resorted to its use no accident resulted. According to the originator of the "lever," this instrument has been used in forty cases, in an almost equal proportion of amputations of the right and left side, and sixty-five per cent. of the cases recovered.[90]

In thin or emaciated subjects, the circulation can be controlled by digital compression of the aorta or external iliac artery, or both may be employed (Gross). It may likewise be effected by the use of a wide roller-bandage placed over the external iliac and held in position by an elastic bandage. The latter should be about two yards in length, its centre being placed between the anus and tuberosity of the ischium; the anterior part of the bandage is brought above the crest of the ilium, the posterior portion crossing the sacro-sciatic notch and meeting the anterior above the iliac crest; both are firmly held in position by an assistant. This method of preventing hæmorrhage from both anterior and posterior flaps has been resorted to in four cases by Jordan Lloyd, of Birmingham, three of which recovered.[91]

In 1876 Trendelenburg,[92] of Rostock, devised a steel rod fifteen inches long, one-fourth of an inch wide, and one-eighth of an inch thick, with a movable point attachment which is to be pushed through the soft parts in front of the joint, an inch above the level where transfixion is to be made with the knife. "The rod having been pushed through the soft parts, the point is removed and a rubber tube wound around the protruding ends of the rod in figure of 8 turns. In this manner compression of all the soft parts in front of the joint is effected, and the flap can be made without loss of blood. After the vessels divided in the anterior flap have been ligated, the rod is introduced through the soft parts behind the joint in a similar manner before the posterior flap is made." Although tedious in its performance, this method of controlling hæmorrhage is thoroughly practicable and promises good results. It has been successfully resorted to by Varrick in a case of traumatic amputation in a subject very anæmic from hæmorrhage.[93]

Methods.—Although a large number * of methods of amputation at the hip have been devised, only a few of them are of practical value, and are, therefore, commonly employed. The methods which will be considered are, that by musculo-tegumentary flaps, that by cutaneous flaps and circular division of the remaining soft parts, and that by a high circular amputation with subsequent excision.

Musculo-tegumentary Flaps.—Amputation at the hip can be most quickly accomplished by means of antero-posterior muscular flaps, of which the anterior is made by transfixion, and the posterior by cutting from within outward. With able assistance the operation can easily be performed in less than twenty seconds. At least three assistants are required in this, as in all amputations of the hip. One of these is entrusted with the control of the circulation in the limb, the second follows the knife to grasp the flap before the artery is divided (Fig. 160, Hueter) and then to retract it, and the third takes charge of the condemned limb.

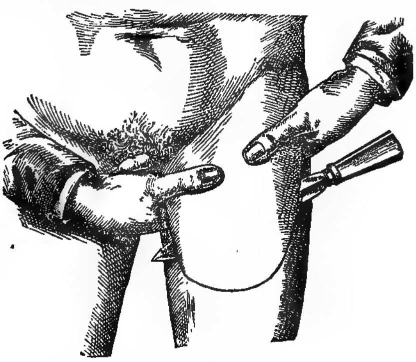

FIG. 160.

The patient's body having been brought to the foot of the table, the nates are made to project over its edge, and the scrotum and sound thigh are held out of the way. While the condemned limb is slightly flexed, the operator, standing on the left side, enters the point of an amputating knife, the blade of which is at least a foot long, midway between the anterior superior spinous process of the ilium and the trochanter major. It is carried deeply into the limb in a direction parallel to Poupart's ligament, across the anterior surface of the joint, which is thus opened and made to issue on the inner surface of the thigh close to the perineum and just in front of the tuberosity of the ischium. Transfixion accomplished, a broad rounded flap, five to seven inches in length, is made by carrying the knife downward in front of the bone and cutting outward. This flap is at once reflected and held out of the way. By a transverse incision on the head of the bone the capsule is then widely opened, while the limb is forcibly abducted and everted Hyperextension then causes the head of the bone to start from its socket with a "popping" noise when the ligamentum teres is cut. The knife being then introduced behind the head

* According to Ashhurst there are forty-five.

of the femur, the posterior portion of the capsule is divided and a posterior flap four inches in length is cut from within outward (Liston). When the operation is made on the right side, the knife is entered from the inner side just above the ischial tuberosity. When the posterior flap is cut from within outward, the cutaneous margin of the wound is generally irregular and not well suited for close coaptation with the anterior flap. It is advisable, therefore, particularly in robust limbs, to either outline this flap by an incision through the skin, or to cut it altogether from without inward (Fig. 161, Esmarch), (Manec). Indeed, both flaps may advantageously be cut in this manner (Guthrie).

The great advantage of the operation just described is in the rapidity with which it can be executed; its disadvantages are in the excessively large wound which it leaves, the tendency to the retention of pus in the intermuscular spaces, and the great probability of excessive hæmorrhage from the posterior flap.

A wound better suited for drainage is that made by lateral flaps. In this form of operation a semicircular incision is made, beginning at the tuberosity of the ischium, and terminating on the outer side of the femoral vessels in the centre of the groin. The incision crosses the outer surface of the thigh four or five inches below the trochanter. The flap thus outlined is then reflected over the latter and the joint opened. The inner flap is then made by cutting from within outward.

FIG. 161.

Tegumentary Flap Method.—This is an admirable method to overcome the superfluity of muscular tissue in the wound and the consequent tendency to purulent infection, and it is, therefore, preferred by a number of operators, among whom are Agnew and Volkmann. The operation is described by Agnew as follows: "The surgeon makes a semilunar incision in front of the limb, with its convexity downward, and, commencing midway between the anterior superior spinous process and the trochanter on the outside, descending the thigh in a longitudinal direction for five inches, then passing across the front of the limb in an oval course, adding thereby an inch to the length of the flap, and, last, ascending the inner border of the thigh, and terminating one inch below the ramus of the pubes. The integument is now rapidly dissected up from the deep fascia and intrusted to the fingers of an assistant."

The next step is to isolate the femoral vessels above the origin of the profunda, and to apply separately to the artery and vein a strong ligature.* By displacing the pectineus muscle the obturator artery can be readily found and ligated below the obturator membrane.

The limb being now raised, the surgeon proceeds to cut a semilunar tegumentary flap from the back of the thigh, one inch shorter than the anterior. With an amputating knife the muscles are then severed circularly in front of the joint, "when after liberation of the head of the bone as in other methods, the operation is completed by dividing through the soft parts posteriorly." According to Agnew, this operation can be completed in forty seconds.

Circular Amputation.—In order to make a smaller wound, and to divide the vessels where they are smaller, a circular amputation of the thigh at the lower part of the upper third is made. This may be accomplished by a single incision in thin subjects, while in robust extremities it is preferable to resort to a double incision. When the amputation in this part is effected, all the blood-vessels that can be recognized must be ligated. An incision is then made along the outer side of the stump from a point two inches above the trochanter to the circular wound, and dividing everything down to the bone (Dieffenbach). The operator then seizes the stump of the femur with a lion-jawed forceps, and while the edges of the vertical incision are separated by an assistant, the soft parts, including the periosteum, are stripped from the bone, and the capsule is opened and disarticulation effected as in other procedures.[94] In 1880, Mr. Furneaux Jordan, of Birmingham, published a method of amputating at the hip which does not differ essentially from the method just described. In his operation the outer incision is first made, disarticulation is effected, and the circular incision forms the last step of the operation.[95]

Finally, mention must be made of the methods of Verneuil[96] and Ed. Rose, who, in amputating at the hip, treat the lower extremity as they would a neoplasm that is to be removed, cutting from without inward, and tying each vessel as it is encountered. A shorter internal and longer external incision is made through the skin when the femoral artery and vein are to be divided between two ligatures. The incisions are then gradually carried through the muscles in front and on the outer side until the articulation is reached, when, after disarticulation has been effected, the adducted muscles are divided last of all.

Amputations at the hip of necessity present a deplorable mortality. Of 633 cases tabulated by Dr. F. C. Sheppard for Ashhurst, 393 terminated fatally, and in 20 the result was undetermined. The general mortality of the operation is, therefore, 64 per cent. The most unfavorable results obtained are those from military practice. Of 249 cases of this character in which the result was ascertained, including 66 operations performed during the War of the Rebellion, only 27 patients recovered, the mortality being 89.1 per cent;[97] 25 of the 66 cases referred to were primary amputations, of which 3 recovered; 23 of the operations were secondary, and all terminated fatally. Of 9 secondary operations, 2 survived, and of 9 reamputations, 6 recovered. Of 71 cases of hip-joint amputation for injury in civil practice, 47 died, the mortality being 66.1 per cent. Of 276 cases of hip-joint amputation for disease, of which 15 were undetermined, 105 terminated fatally, the mortality being 40.2 per cent.[98]

Joseph Ransohoff.

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* Volkmann divides the vessels between two ligatures.

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AMYLENE. *Valerine*, C_5H_{10}. Amylene is a volatile and inflammable ethereal fluid of an unpleasant odor, resembling that of cabbage. It was experimented with by Snow in 1856, as an anæsthetic, and proved itself powerful, after the manner of chloroform; but proving itself also capable of killing, it never came into accepted service.

Edward Curtis.

AMYLIC ALCOHOL. The title *amylic alcohol* is applied to two associated isomeric alcohols of the composition $C_5H_{12}O$, which occur as the principal ingredients of so-called *fusel-oil*, an acrid, oily liquid forming as one of the products of alcoholic fermentation. Amylic alcohol is obtained from fermented grain or potatoes, by continuing distillation after the ordinary spirit has ceased to come over. It is a colorless, oily fluid of a peculiar disagreeable odor, and an acrid, burning taste. It is nearly insoluble in water, but dissolves freely in alcohol, ether, and volatile oils.

Amylic alcohol affects the animal system after the general manner of common alcohol, but it is locally more irritating and constitutionally more unpleasant in its operation. It is rarely used in medicine, but is valuable as a source of artificially-made valerianic acid. It is not now officinal in the U. S. Pharmacopœia. *Edward Curtis.*

AMYLOID DEGENERATION. (From *amylum*, starch, as the amyloid material resembles starch in certain chemical reactions. Also called waxy, lardaceous or albuminoid degeneration. French, *Dégénérescence amyloïde;* German, *Amyloidentartung*, also *Wachsentartung*, *Speckentartung*.)

By the term *amyloid degeneration* is meant the appearance in certain tissues of the body of a clear, colorless, homogeneous, translucent, highly refractive material, which, from its resemblance to wax, has led to its designation as waxy material, and to the process as waxy degeneration; further, from its behavior with iodine and sulphuric acid, Virchow gave it the name of amyloid material, he supposing at the time that the substance was similar or closely allied to starch. Repeated chemical analyses have shown, however, that it is not a hydrocarbon, but a nitrogenous material resembling in some respects albumen, but differing from the latter in its reactions, to be presently mentioned, and also in its resistance to both putrefaction and digestion with pepsin.

Amyloid material reacts to certain reagents in a very characteristic way. The application of a watery solution of iodine in iodide of potash changes it to a mahogany-brown color, whereas tissues not the seat of this change assume a yellow tint; further, addition of sulphuric acid produces a blue color in amyloid material. One of the aniline dyes, methylviolet, is a very delicate test, the amyloid material taking on a rose-red color, the other portions a blue.

Amyloid degeneration never occurs as a primary disease, but represents the secondary result of a disturbance of nutrition, dependent either upon long-continued suppuration, especially of bones, or upon syphilis, tuberculosis, chronic malaria, and occasionally cancer. It shows a special predilection for certain organs, notably the liver, spleen, kidneys, and mucous membrane of the intestine, especially of the lower portion of the ileum and the colon; whereas in the epidermis, glands of the skin, lung, bones, and nerves, it has never been observed, no matter how far advanced the process might have been in other parts of the body.

When present in small amount amyloid material can only be detected by the microscope. In larger amount the appearances, though differing with various organs, are so characteristic as not to be readily overlooked. In general, it may be said that the organs are enlarged and of an increased density; the cut surface is pale, dry, and shows a homogeneous, translucent, and waxy appearance, greater or less in degree according to the stage of the degeneration. Thin slices of the organ, especially of the liver, when held up to the light, show a much greater translucency than do similar slices of normal organs. The mucous membrane of the intestine, when the seat of this change, is thickened, dry, and translucent, looking exactly as if mucilage had been brushed over it.

Microscopically examined, amyloid material shows an entire absence of definite structure, it being a homogeneous, glass-like substance of a high index of refraction, unaffected by ordinary reagents, but staining brown with iodine, and rose-red with an aqueous solution of methylviolet, by either of which means its presence in tissue is readily confirmed.

In general, the seat of the amyloid change is primarily in the middle coat of the smaller arteries; later, it may involve connective tissues, and possibly, in some organs, epithelial structures; but this latter point is still under discussion; all that can be said is that the epithelial cells disappear, either by conversion into amyloid material, or else by atrophy from pressure from the encroaching material.

In the liver the amyloid change begins in the small branches of the hepatic artery distributed to the so-called middle zone of the liver acinus; hence its presence can often be detected in early stages as a translucent ring containing in its centre the red and opaque central region of the acinus, and surrounded by the paler peripheral zone. Later, all parts of the acinus may become affected, showing, as a whole, appearances like those previously described.

In the spleen, the follicles alone may be affected, producing the so-called sago spleen, the follicles being enlarged and translucent, resembling grains of boiled sago, or the pulp and follicles may be both degenerated, producing the so-called ham or bacony spleen, from its resemblance in its dense, dry, dark, translucent surface, to these familiar objects.

In the kidney the afferent arteries of the glomeruli are, as a rule, first affected, then the capillaries forming the glomerular tuft; then the efferent vessels; next, the capillaries surrounding the convoluted tubules; and, finally, the membrana propria of the tubules. The arteries and capillaries in the pyramids are often affected early in the disease.

In the intestine, vessels and unstriped muscle-fibres become amyloid.

The important question in connection with amyloid de-

generation is one which is still under controversy, and hence can receive but passing notice in an article of this character. It is whether the amyloid material is formed *in loco* by a metamorphosis of the albuminoid material of the part itself, or whether it represents the result of an infiltration into the part, from the blood, of a material formed elsewhere in the body. Its general distribution and its primary presence in the walls of blood-vessels favor the latter idea, but against it is the fact that no material at all resembling amyloid has ever been found in the blood.

The amyloid change is a slowly progressive one, occupying months and even years. Recovery never occurs where the process is at all advanced, and it is questionable whether, even in milder grades, such a result is possible, though Frerichs, of Berlin, records a case of the latter kind, sent by him to the baths of Aix-la-Chapelle.

The disease may often be diagnosticated during life, where, one of the predisposing causes above mentioned being present, one finds the liver and spleen enlarged, and the urine abundant in amount and containing considerable albumen.

As regards its importance in interfering with the functions of organs, it may be said that the portions affected are no longer capable of functional activity; but it is often surprising to see how extensively a liver may be affected, and yet be capable of secreting sufficient bile, at least.

Individuals with amyloid degeneration of the organs show a marked degree of anæmia, and usually die under conditions of hydræmia or marasmus.

There is no treatment known for the restoration of parts which have become amyloid, but the physician's endeavors should be devoted to the treatment of the predisposing diseases previously mentioned. Of far less importance than the general form of the disease described, is a local form of amyloid degeneration occurring in lymph-glands, thrombi, and conjunctiva. It always occurs in previously diseased parts, and possibly may be more closely allied to hyaline degeneration than to amyloid.

In the same category are to be included the so-called corpora amylacea, microscopic bodies showing a series of concentric markings, and hence closely resembling starch-granules. To iodine they give a blue color, and to methyl-violet a red color in their centres, though only occasionally throughout. They are found in the central nervous system, especially where there is an active growth of neuroglia, as in the chronic form of ependymitis of the ventricles of the brain, and in the neighborhood of degenerated nerves.

Large corpora amylacea of a snuff-brown color are frequently seen in the prostates of old men.

The significance of these bodies in either of the above situations is unknown. *W. W. Gannett.*

ANÆMIA, HYDRÆMIA, AND PLETHORA, GENERAL AND EXPERIMENTAL PATHOLOGY OF. *Normal Regulation of the Composition of the Blood.*—The blood, as it circulates in the body, is constant in composition only within certain limits. It is at all times necessarily undergoing variation from fresh material, in the shape of water and the solutions of different substances being added to and taken from it concomitantly with the acts of digestion and tissue change in which it participates. Besides these ever-varying changes, in quality as well as quantity, the blood, as a whole, adapts itself to the alterations occurring in the general nutrition of the body, increasing as it grows, decreasing as it emaciates, thus ever keeping pace with the exigencies of the system, and preserving a certain pretty definite proportion to the weight of the body —amounting in man to about eight per cent. (Bischoff). To maintain this relation the regulative functions must be continually at work, and their mode of action we will now cursorily pass in review.

Regulation of the Amount of Water.—Probably the most frequent changes in the composition of the blood are brought about by variations in the quantity of *water* present. After a meal, and still more after a full draught of water, the fluid portion of the blood is for the time increased. It is, however, soon reduced again by an increased elimination either by skin or kidneys, or both combined. In summer, when the vessels of the skin are dilated by the heat and hence cutaneous activity is great, the excess of water will be removed by transpiration, the urine becoming comparatively scanty. In winter, however, the case is reversed. The skin is inactive and the brunt of the labor is put upon the kidneys, which then secrete abundantly. When, after muscular exercise or exposure to heat, much water has been removed by evaporation from the skin, or after copious watery stools the blood has been deprived of its needful fluidity, the vessels begin to absorb moisture from the tissues. This process gives rise to the sensation of thirst, which in turn leads to drinking the needed water.

The harmful effects upon the system caused by non-compensated desiccation of the blood are shown in the case of cholera, where repeated watery stools rapidly produce a marked thickening of the blood. My own experience with sunstroke shows a similar condition to exist as the result of excessive perspiration. On post-mortem examination the right ventricle will be found gorged with venous blood, and accompanied by intense venous congestion of the lungs arising from inability of the heart to propel blood of such altered consistence through the pulmonary capillaries. In the only case where I attempted venesection, not more than a few grams could be made to flow from the median basilic vein, the blood being distinctly thickened. Large enemata of cold (ice) water, which were retained, we found one of the best means of treatment, the water being absorbed by the large intestine, thus liquefying the blood, while its low temperature helped to cause a rapid diminution of the intense fever so characteristic of insolation. (Cases having temperatures of 110° F. recovered.)

Regulation of the Amount of Solid Ingredients.—There is no evidence whatever that an overproduction of the *corpuscular elements* occurs during health; indeed, the experiments on artificial plethora, to be touched on later, show that such a condition of polycythæmia can only be of quite temporary duration, the excess being removed by increased corpuscular disintegration. During certain diseases, however, as leukæmia, etc., more white corpuscles than normal are produced.

Excessive amounts of the *unformed solid materials* of the blood taken into the system as food, when not stored up in the body as fat, show themselves in the urine. The albumins reappear principally in the form of urea (to a less degree also as uric acid and creatinin), and it is immaterial whether the excess of albumin is derived from without, in the shape of food, or from the tissues of the body itself, as the result of increased consumption from muscular exercise (Flint, *New York Medical Journal*, 1871, and Pavy, London *Lancet*, 1876, experiments on the pedestrian Weston), or in consequence of fever.

The *inorganic salts* are eliminated chiefly by the kidneys; to a less degree in the sweat and fæces.

Foreign bodies introduced in solution into the circulation are removed often with great rapidity. Some, such as potassium iodide, quinine, atropine, and the alkaloids in general, pass out in the urine under their own form, others are changed in the system and escape as derivatives. For instance, the vegetable acid salts of the alkalies become carbonates, benzoic becomes hippuric acid, the oleo-resins of copaiba, cubebs, etc., are converted into resinous acids, all of which appear in the urine. The kidneys play the chief part in this depurative process, though the lungs, skin, liver, salivary, intestinal and (in the female) the mammary glands are also more or less actively engaged, different drugs having evidently certain seats of predilection for their elimination. Thus many volatile bodies escape by the lungs. This is true of ether and chloroform and their allies. The allyl sulphide, the characteristic odorous principle contained in onions, is exhaled by both lungs and skin together. The purgative salts are, after absorption, eliminated from the intestinal walls, and many drugs reappear in the milk. In cases where permanent combinations are entered into between the blood and such substances foreign to it as materially

interfere with its functions, serious disturbances or death of the organism take place. Thus the union between carbon monoxide and the hæmoglobin of the corpuscles is a permanent one. This irrespirable gas is neither consumed by oxidation in the tissues nor expelled by respiration, since hæmoglobin has a greater affinity for carbon monoxide even than for oxygen. An oxygen famine consequently ensues, which is of more or less serious import according to the amount of hæmoglobin rendered unserviceable.

Organized bodies entering the circulation are eventually removed unless death occur. In relapsing fever, for instance, the blood, during the paroxysms, is found to be full of the spirochaeta Obermeyeri, yet these disappear entirely after recovery. They probably die, their remains disintegrate, and are removed either while still in the blood itself or after being carried to the spleen and perhaps some other organs. The spirilla are not found in the urine, and consequently are not eliminated by the kidneys. Similar processes occur in other infectious diseases.

In cases where the regulative functions are not powerful enough to remove from the blood either the living organism itself or the septic material which it elaborates, the economy is forced to suffer accordingly, illness and death resulting.

ANÆMIA.—The term "anæmia," *i.e.*, lack of blood, has come to include not only absolute quantitative alterations in the blood volume, but in a narrower sense also it is used to designate those qualitative changes connected with a decrease in the amount of red corpuscles, more properly called "oligocythæmia" (Gr., *oligos*, few, small; *kytos*, cell), or, simply, "oligæmia."

Absolute diminution in quantity is usually termed "acute anæmia," while qualitative changes are broadly grouped together under the title "chronic anæmia," which includes, besides the anæmia resulting from debility, chlorosis, leucocythæmia, idiopathic (pernicious) anæmia, and their allied affections—conditions which are perhaps more accurately designated by the word "spanæmia" (Gr., *spanos*, poor).

Acute anæmia is the result of hæmorrhage from any cause. The total quantity of blood in the body is reduced, but the elements of the quantity remaining keep their relative proportions, with the exception perhaps of the white blood-globules, which will be found to be in excess; for, owing to their adhesion to the walls of the vessels and to their lying in the peripheral zone of the arterial current, a proportionately fewer number of white than red will be swept away by the escaping blood (Cohnheim). The effects of a hæmorrhage are proportionate to its degree. A small quantity of blood may be withdrawn from a healthy individual without any perceptible result, but if frequent small bleedings occur, as happens in cancer, metrorrhagia, etc., the consequences for the system, and the degree of anæmia produced, will be far more profound—from reasons to be discussed later—than those caused by one large hæmorrhage.

Effects of Moderate Acute Anæmia on Blood-Pressure.—1. *Immediate.*—When moderate amounts of blood are successively drawn from a vessel, no lasting effects on the blood-pressure are observed. Arterial pressure sinks while the blood is flowing, but rises again to its original level as soon as the flow is stopped. In this way as much as one-fourth of the blood in a dog's body may be withdrawn without immediate effect on the arterial pressure. The vaso-motor regulative forces, by causing contraction of the vessels—especially those of the skin, as is evident from its pallor and coldness—keep the blood at its original pressure, and as the consistency of the blood is unchanged, and hence the amount of friction against the vessels unaltered, both the action of the heart and the speed of the current remain, for the time at least, unaffected by the loss.

2. *Secondary.*—Though the immediate effects on the circulation itself may be but very slight, the results for the system at large are not so indifferent. Normally the amount of blood in the body is only of such quantity that when one apparatus is in a state of functional activity, and hence requires an increased supply, blood has to be withdrawn from other parts of the body. This is shown by our daily experience of disinclination for active mental or physical exercise, when, after a full meal, there is a determination of blood away from the nerve-centres, and muscles, and to the alimentary canal; and, contrariwise, of inability to perform digestion well if severe muscle- or brain-work be persisted in nevertheless.

After any considerable hæmorrhage, therefore, whether from a single copious loss of blood, or often repeated bleedings, the functional activity of the body generally, with the exception of the hæmapoietic (blood-forming) function, will necessarily be in abeyance. For, all the remaining blood being required for the activity of the blood-forming organs, now stimulated beyond their normal production, to the regeneration of the blood-tissue, the other organs are forced, from lack of material, to work at a minimum of their capacity. Consequently we see after hæmorrhage bodily and mental lassitude, inability to perform well the acts of digestion, an enfeebled action of the heart (and hence, as a secondary result, diminished blood-pressure), and general relaxation of all the tissues.

We have said that the immediate effects on the circulation were, owing to the unaltered consistence of the blood, very slight. This unaltered condition, however, does not long obtain, for almost immediately regenerative processes, tending toward a restoration of the blood, begin, these being inaugurated by absorption of water from the tissues, and a condition known as hydræmia is the result. A reversed current of transudation sets in from the tissues toward the vessels, and this backward flow will continue until the normal equilibrium between intra- and extra-vascular pressure is found. It is this rapid resorption which after sudden large hæmorrhages gives the pinched and drawn expression to the face, and causes the parched mouth and feeling of thirst,—symptoms which soon disappear when sufficient water has been ingested to supply the demand of the desiccated tissues.

Frequently repeated hæmorrhages become the more injurious to the system than a single large one, because they maintain a constant state of hydræmia; for, before regeneration can have been completed, a fresh bleeding occurring, the already hydræmic blood becomes still further diluted and less fit for functional work—less fit for supplying those very organs by which its own regeneration is effected—and hence the regenerative process may be postponed indefinitely.

In addition to the hydræmic state there is also after acute anæmia a condition of moderate leucocythæmia. As a stream of lymph, rich in white blood-corpuscles, is continually flowing into the subclavian veins from the lymph-ducts, a relative increase of the white over the red corpuscles soon takes place. Furthermore, from the withdrawal of a certain quantity of red blood-corpuscles, a state of oligocythæmia (disk-scarcity) occurs. It has been found (Hünerfauth, Lyon, Buntzen, Von Ott) that after a hæmorrhage the red corpuscles continue to decrease for several days (owing probably to lessened production from suspended hæmapoiesis) before regeneration begins, the period varying according to the amount of blood lost. The time required for complete regeneration likewise varies, occurring sooner in moderate, later in severe hæmorrhages. The limit may be put down at from three to five weeks in cases where from three and a half to four and a half per cent. of the body's weight of blood has been lost (Lyon: *Virchow's Archiv*, Bd. 84, 1881).

In his experiments on dogs, Von Ott, of St. Petersburg ("*Ueber den Einfluss der Kochsalzinfusionen auf den verbluteten Organismus im Vergleich mit andern zur Transfusion verwendeten Flüssigkeiten*," *Virchow's Archiv*, Bd. 93, 1883), found that when hæmorrhage had been followed by an injection of an equal amount of normal (six-tenths per cent.) sodium chloride solution, regeneration was carried to even beyond the normal limits, a true polycythæmia resulting, and lasting for several weeks (thus, in one case, half as many more red disks than were originally present were found at the end of about two months after the transfusion!), the number of corpuscles gradually sinking back to normal. He points to the analogous

overproduction of reparative tissue in redundant granulation, in bony calluses, etc., as an explanation of this fact.

That after hæmorrhage the disintegration of red disks is diminished is shown by the light color of the urine and bile, which derive their pigments from the destructive metamorphoses of the hæmoglobin.

Curiously enough, Von Ott found that the unformed elements, the soluble albumins of the blood, were the last to be replaced.

Effects of Severe Acute Anæmia.—In severe hæmorrhage, where more than one-half of the blood has been lost, the effects on the system are of a more severe nature than those just described. The arterial pressure falls, and remains low in spite of arterial contraction, because the quantity of blood remaining in the vessels is too small to properly fill them even when they are reduced to their minimum calibre. As the heart receives less blood both into its ventricles and in its muscular substance, its contractions become more feeble; the stimulus, also, of a full supply of blood to the cardio-inhibitory centres being absent, their restraining action is lessened, and the heart-beats become more rapid but lose in force. The blood-pressure consequently tends to become still further reduced. In spite of a reversed current of absorption taking place, as already alluded to, the quantity of blood remaining is too small to carry on the functions of the body, and a general lowering of all the vital processes occurs in the meanwhile, so that a secondary rise of pressure either does not take place at all, or is insufficient. In these cases, death will sooner or later ensue, unless some means are taken to artificially raise the arterial pressure; for it has been found by experiments on animals that the mere fact of the pressure being normal is in itself sufficient to maintain life, even after what would otherwise have been a fatal hæmorrhage. The only certain and immediate means to effect this end is to practise transfusion (see Transfusion).

After many disastrous experiments on man, unfortunately, as well as on animals, it was found that transfusion, whether directly or indirectly, of blood of another species was usually followed by fatal results. Then for some time the transfusion of homologous blood was practised with more or less success. Experiments on animals, however, gradually led to the belief that the blood used might be equally well replaced by an indifferent sodium chloride solution. Von Ott has placed our knowledge on this subject on a secure experimental basis (loc. cit.). He found that after depriving dogs of as much as even two-thirds of their estimated amount of blood, and replacing the quantity lost by an equal quantity of a normal sodium chloride solution (six-tenths per cent.), life was in all instances preserved, and the animal did not even suffer any subsequent apparent discomfort. Comparative experiments made with defibrinated as well as with normal blood of other dogs, and with the blood serum of horses, showed the remarkable result that in all cases the corpuscular as well as albuminoid elements of the tranfused material were destroyed in the body before the formation of new blood began. The terms "transplantation" and "substitution," proposed by Panum, cannot therefore be rightly used. This destruction occurred even when blood was reinjected, after defibrination, into the very dog from which it had just been taken. Von Ott determined by quantitative examinations, that after transfusion of salt solutions complete regeneration of the corpuscular, albuminoid, and saline elements of the blood occurred twice as rapidly as when transfusion of blood itself had been performed. As in man, hæmorrhages amounting to as much as two-thirds of the total amount of blood rarely, if ever, occur, this simple procedure of transfusing a six-tenths per cent. salt solution can, and should be used after any severe hæmorrhage where reaction does not take place, or in which there is subsequent collapse.

Regarding the nature of the processes concerned in the *regeneration* of the red corpuscles, the most conflicting opinions exist (see Blood), nor can our knowledge on the subject take definite shape until the exact site or sites of the cytogenetic (Gr., *Kytos*, cell; *genesis*, generation) function and its mode of action are satisfactorily settled. The following is a brief summary of the most generally accepted views on the subject existing at the present time.

The white blood-corpuscles originate in the spleen, the lymphatic glands, the marrow of the bones (and perhaps also in the liver), and from the division of pre-existing ones.

The red corpuscles, by many, are supposed to be derived from the white, or from the embryonal form of nucleated red corpuscle found in the marrow during adult as well as fœtal life. Rindfleisch and Malassez hold that these nucleated red corpuscles lose a part or the whole of their colored protoplasm; the separated portion, at first globular, assumes later a flattened shape, and is then carried into the circulation as a perfect red corpuscle. The nucleus, with some of the surrounding colored protoplasm, remains behind in the bone marrow, to give rise to new red corpuscles by a repetition of this budding process. Certain giant cells found in the fœtal liver, spleen, and marrow are considered by some to have cytogenetic functions, the mode of formation of the red corpuscles from them being similar to that just described. This view has been particularly elaborated by Foà and Salvioli (*Archivio delle scienze mediche*, vol. iv.). Both of the above explanations, however, rest as yet on too slender evidence to gain general acceptance.

Bizzozero is of opinion that the karyokinetic or indirect nuclear division (see Cell) of pre-existing red blood-corpuscles is the only source that can be given for the origin of the colored corpuscle in the adult, which strictly satisfies the demands of scientific inquiry. Bizzozero first described this division as observed in the blood of the frog (*Annali universali di medicina*, 1869), and later in the blood of adult man (*Centralblatt für die med. Wissensch.*, 1881). These observations have since been confirmed by Flemming and Arnold, and again, quite recently, by Aly and Eberth ("*Ueber die Vermehrung der rothen Blutkörper.*" *Fortschritte der Medicin*, 1885). This karyokinetic division has been seen by Bizzozero, in its very act of occurrence, even in warm-blooded animals, and in cold-blooded ones, he states, it can be observed with ease.

Those elements which he calls "young red blood-globules," found in the marrow of mammalia, and in the spleen and kidneys of the oviparous vertebrates, are regarded by him as resulting from this karyokinetic division. A portion of them, after becoming flattened and increasing their amount of hæmoglobin, finally pass into the blood-current as perfect red corpuscles, while others, after attaining a certain growth, remain to continue this multiplying process, by constant re-division. In adult mammals they lose their nuclei, in some manner undescribed. From his experiments he is inclined to look upon the pre-existing blood-corpuscles as the sole source of regeneration in adult individuals, and in support of this view he instances the following facts in proof: First, abundance of karyokinetic forms constantly to be found in the cytogenetic organs of the different classes of animals (marrow of mammals, birds, reptiles, and tailless amphibia; spleen and renal lymphoid bodies of fish). Secondly, the rapidity with which the process occurs (ten to fifteen minutes in cold-blooded animals). Thirdly, the variation in the number of elements met with undergoing karyokinesis according to the demands of the system; thus, they are very plentiful after bleeding. Fourthly, from the very first period of embryonal life all through adult existence, there is no period during which these karyokinetic forms are not to be met with. To this last fact he attaches special significance. (For a very interesting account of the whole subject see the article by him: "*Ueber die Bildung der rothen Blutkörperchen,*" *Virchow's Archiv*, vol. xcv., 1884.)

Hayem considers certain small colorless disks—microcytes—found largely in idiopathic (pernicious) anæmia, to be the initial stages of new red corpuscles. Most authors, however, hold rather that these colorless corpuscles are the result of the disintegration of pre-existing ones.

Foà and Salvioli have by embryological investigations shown that the corpuscular changes described by Bizzozero occur in different organs, the site varying with the advancing age of the fœtus. At first they take place anywhere in the circulating medium ; soon, however, the nucleated red corpuscles are found in especial abundance in the liver. They then diminish in the liver, only to increase in number in the spleen. They disappear from the spleen again with advancing intra-uterine existence, increasing at the same time in the bone marrow, where they remain fixed for the rest of life. Only after severe hæmorrhage has it been noticed that in some animals the spleen temporarily resumes its cytogenetic function.

True Plethora.—No idea is more firmly fixed in the popular mind than that certain individuals are habitually too "full-blooded," and that various disorders arise from the body having more blood than is proper to it. In former times this idea was expressed in the custom of annual venesections, resorted to generally in the springtime ; a custom still maintained by the peasantry in some parts of Europe.

Even in the text-books the occurrence of plethora and its supposed consequences are often alluded to. Its indications are thought to be a red face, a high-tension pulse, shortness of breath, liability to headaches and vertigo, and finally apoplexy, conditions that frequently obtain in stout elderly people, but which in reality are due to vaso-motor or organic cardiac disturbances. Again, the suppression of periodic discharges of blood, as menstrual or hæmorrhoidal, are considered to be a cause of plethora, and one of the objections formerly urged against the bloodless method of operating by means of Esmarch's bandage was, that an excess of blood, above that required for the needs of the economy, would be left in the body.

No chapter in general pathology shows more plainly the futility of inventing explanations, instead of putting the phenomena to be investigated to the crucial test of experiment. Worm Müller's experiments (*Bericht der Leipziger Ges. Math.-Phys. Kl.*, 1873. *Transfusion und Plethora*, Christiania, 1875) on the production of artificial plethora in dogs, by injecting blood into their vessels, show that no permanent increase of blood-pressure—on which all the evils of the plethoric state are supposed to depend—can possibly be produced. The course of his experiments was as follows : If defibrinated blood be injected into the jugular vein of a dog, the arterial blood-pressure, as measured in the carotid, femoral, etc., will be observed to rise only so long as the injection is continued. It falls at once to its original level again when injection is suspended. In this way more and more blood may be introduced until the original quantity in the body is doubled, the blood-pressure rising with each fresh injection, and then falling again, but each time with increasing slowness, to its original level. If injection be now continued, the occurrence of sudden marked falls and rises in the arterial pressure indicates approaching death. The regulative mechanism is evidently unable to cope with quantities exceeding a certain limit, and dogs do not permanently survive the introduction of double their original volume of blood, though they may live a few hours after. Even the injection of an equal amount, *i.e.*, till the quantity of blood in the body is doubled, is usually followed by death in a few days, though in the beginning it might seem, from the dog's behavior, as though no evil effects had ensued. Dogs in whom a quantity equal to one-half the amount of blood already present was injected, remained entirely unaffected.

If the experiment be made in an animal whose blood-pressure has been previously reduced by bleeding, the effects are somewhat different from the foregoing, namely, the pressure will rise while fresh blood is being injected, until the original height of mercury is reached ; after that it will pursue the same course as above.

The manner in which the system prevents blood-pressure from rising to a degree dangerous to the integrity of the vessels depends on the nervous mechanism of the arteries adapting their calibre to the amounts they are called upon to contain. Normally the vessels are in a state of rather marked tonic contraction, but they relax, enlarging their capacity with each fresh injection, and continue to do so until, as we have seen, death suddenly occurs without a permanent elevation of pressure having been at any time effected. On examining the body of an animal thus experimented upon, it will at once become evident where the injected blood has been stored. All the vessels of the abdominal organs will be found to be greatly dilated and gorged with blood, while in the extremities, skin, nervous system, etc., no unusual hyperæmia will be present, nor is there any œdema of the subcutaneous connective tissues. It is, therefore, upon the abdominal viscera, so abundantly supplied with vessels, that the burden has fallen. The abnormal stretching of their vessels, however, even when non-fatal quantities have been introduced, is not without effect, for Müller found that for some time after the experiment the dogs used were exceedingly sensitive to hæmorrhage. Bleeding such an animal to an amount which in a healthy dog would be without effect was followed by a fall and a persistent depression in arterial pressure which often resulted fatally, showing that the abdominal vessels had not regained sufficient tone to react promptly, and, by contracting, to bring the pressure back to normal.

Müller demonstrated by a series of observations upon the blood and upon those products of tissue metamophoses that show themselves in the urine, that the injected blood is soon removed from the body. First of all the plasma disappears, two to three days sufficing where sixty to eighty per cent. of the original quantity of blood had been injected, and in about a week the number of red blood-corpuscles is reduced again to normal. At the same time the quantity of urine and of the urea eliminated is greatly increased. Profuse urination indeed often begins during the performance of the experiment, and the dogs may be observed constantly urinating in large quantities for the first few hours following. The augmented quantity of urea produced points directly to increased metabolism going on in the body of the albuminous materials introduced with the plasma of the blood injected.

Of course, no such degree of plethora as we have seen can be safely produced in dogs was ever supposed to occur in the human body. How insignificant, therefore, in effect must the small quantity of blood be which is retained in the body from an omitted menstruation, or even the larger amount forced into the general circulation on applying the elastic bandage.

The myth of the "plethoric habit" may, therefore, be forever banished from pathology, and it will be found that the symptoms which were formerly laid at its door can be more readily explained by referring their causation to disturbances of the nervous system. The flushed face, throbbing carotids, headache, faintness, etc., when not due to organic heart disease, are generally caused by disturbed vaso-motor innervation, the result of habitual over-feeding combined with bodily inactivity, and the indigestion consequent thereto. Let the alimentary canal be thoroughly emptied of its contents by a vigorous purge, and these "plethoric" symptoms will usually disappear. So, too, the various nervous symptoms attributed to the supposed plethora resulting from suppressed catamenia may be explained by the general nervous disturbances occurring at the menstrual period, augmented by the effects on the mind of the manifold evils which in the popular, and only too often in the medical estimation also, are supposed to flow from amenorrhœa, when in reality the absence of the menses is only one of a train of symptoms of some underlying cause.

Having considered the more important of the consequences arising from alterations in blood volume, real and supposititious, let us now turn to the investigation of those changes in the circulation, and system generally, caused by alterations in quality. These may obviously be divided into, first, those affecting the plasma ; second, those affecting the corpuscles, and into combinations of both conditions.

Changes in the quality of the blood affect the system, firstly, by altering the normal coefficient of friction existing between the vessels and their contents ; secondly, by affecting nutrition, and hence the functions of all the organs ; thirdly, by changing the normal ratio of osmosis

existing between the intra- and extra-vascular fluids; fourthly, by modifying the normal interchange of gases; and fifthly, by the altered plasma affecting the integrity of the corpuscles.

Alterations in the plasma consist in changes in the quantitative relations existing between the water and the substances it holds in solution. Of the latter it is the albumins with which we have to deal within the scope of this article.

Diminutions in the relative quantity of water have already been alluded to in speaking of the effects cholera and sunstroke have in desiccating the blood, and need not further be considered.

HYDRÆMIC PLETHORA.—An absolute increase of the watery elements can, as we have seen, be at best but a temporary condition. It is evident that it must occur after the ingestion of water into the stomach (since it has been found that water injected experimentally into a dog's stomach is soon absorbed), but increased urination and sweating quickly reduce the amount to normal again. As the kidneys are the organs chiefly concerned in regulating the amount of water in the blood (the skin and lungs being but secondary), diseases affecting the integrity of these organs must necessarily influence the composition of the blood. Especially is this true of lesions of the glomeruli, which secrete the watery portion of the urine. Hence we find in the early stages of granular kidney—that form in which the glomeruli are involved *par excellence*—and before cardiac hypertrophy has set in, the urinary secretion diminished. Again, diffuse renal inflammation, by retarding, in consequence of increased resistance, the flow of blood through the vessels, must also diminish the quantity of water eliminated, for the vessels are dilated, and owing to the inflammatory changes affecting their walls friction is increased, consequently the current being spread through larger channels, and having in addition more resistance to contend with, becomes considerably slower (as is the case in all inflamed areas, Cohnheim), and since the amount of urine depends not so much on the quantity of blood in the kidneys as on the rapidity of the current (Heidenhain in "Hermann's *Handbuch der Physiologie*," article, *Harnabsonderung*), it follows that a diminished secretion is the result. This, in cases of acute renal inflammations may at times amount even to virtual suppression.

Another cause of retention of water in the circulation may arise from some mechanical obstruction, generally in the shape of a calculus lodged in the ureter, preventing the flow of urine from the corresponding kidney. Normally, secretion goes on only as long as pressure within the glomerular tuft is greater than that of the fluid surrounding it. The more the intra- and extra-vascular pressures tend to become equalized, the more slowly does the elimination of water take place, until finally it ceases. The functional activity of the unaffected kidney is, however, soon increased to such a degree that the daily amount of water eliminated from the blood presently reaches the normal again, and in the meantime it is probable, though there are no experiments to prove it, that lungs and skin act vicariously, to a certain extent, in maintaining the blood at its normal concentration.

It follows, therefore, from the foregoing, that while a state of hydræmic plethora may, and probably does, exist, it can be but of short duration. Compensatory factors, constantly at work, are ever tending to equalize the balance existing between the various components of the blood.

HYDRÆMIA.—Different from the condition just described is one where, without an increase in the absolute volume of circulating fluid, the relative amount of water it contains is augmented. This is brought about by a diminution of some one of the other elements, of the plasma, and of these albumin is the one affected, a state known as "hypalbuminosis" supervening. Hypalbuminosis occurs as the result of anything causing an increased consumption of albumin on the part of the organism, or, as in hæmorrhage and albuminuria, by direct loss.

We have seen how, after a hæmorrhage, the quantity of circulating fluid is restored by increased absorption of water, a hydræmia resulting proportionate to the amount of blood lost. Any condition causing a loss of the albumin alone, unless this loss be compensated, will similarly produce hydræmia. The albuminuria of the various forms of nephritis is the most frequent cause. Here the patient may, for a long period, be subjected to a constant drain of albumin from the blood, but so long as no other disturbing elements arise to complicate the trouble, the loss can be made good by an increased supply of food, and no ill effects are felt. As soon, however, as the renal lesion becomes so great as to seriously impair the removal of the excrementitious substances from the blood, a condition supervenes leading to derangements of the digestive, of the circulatory, of the secretive and excretive, and, indeed, directly or indirectly, of all the functions of the body. Owing to imperfect digestion and assimilation the loss of albumin is no longer replaced, and a hydræmic state soon makes itself apparent in the forms of œdema or anasarca.

The production of hydræmia in renal disease, though having its ultimate origin in the kidney lesion, may be brought about by immediate causes other than those originating in the kidney itself. Chief among these are disturbances in the circulatory system; for instance, cardiac failure from insufficient compensatory hypertrophy, the influence of intercurrent diseases on the heart, surgical operations, great mental or bodily fatigue, etc., etc. How often is it noticed that patients with granular kidney may go on passing larger or smaller amounts of albumin in their urine for years without the general health being appreciably affected. No loss of strength, no spanæmia, no hydræmia as indicated by œdemas, appetite good, and all functions apparently normal, so long as caution regarding mode of life is exercised. But the susceptibility of such patients to what would be normally regarded as slight disturbances, is too well known to need elaboration here.

The absolute changes occurring in the blood during Bright's disease have been investigated by many observers (Bright, Christison, Andral, Frerichs, Bartels, and others). It has been found that the serum-albumin may be diminished from the normal eight to ten per cent. to as low as five and four per cent., while there has been a corresponding increase of water from ninety to ninety-five per cent., the specific gravity of the serum falling proportionately.

Besides the drain of albumin by way of the kidneys, constant losses from suppuration, continued fever, the growth of neoplasms, prolonged lactation, and all debilitating conditions, cause a state of more or less marked hydræmia.

The most striking disturbance of the economy resulting from hydræmia is the one leading to those transudations of fluid from the vessels into the tissues and serous cavities known as *œdema* and *anasarca*. For a long time it was generally thought that the cause of these conditions was to be sought in the supposed fact that watery blood passed with greater ease through the vessels than normal blood—an inference most natural, seeing that dilute solutions of albumin pass more readily through animal membranes than more concentrated ones—but one which the experiments of Cohnheim and Lichtheim (*Virchow's Archiv*, Bd. 69) have shown not to hold good for the vessels of the living body. They found in their experiments that while hydræmic plethora, induced by the injection of salt solution, caused œdema of the abdominal organs and a collection of fluid in the peritoneal cavity, just as occurs, only to a less degree, in experimental true plethora, simple hydræmia, on the other hand—that is, the replacement of a measured amount of blood by an equal amount of a normal salt solution—caused no œdematous phenomena of any kind to appear. These observers found that so long as the vessel-walls remained normal in structure no increased transudation took place, but that as soon as their integrity was in anywise affected, fluid began to pass through. This was shown by scalding one paw of a dog to cause a local injury of the blood-vessels, after first noting the rate of lymph-flow from corresponding legs, then, upon injecting some salt solution into the jugular, an increased quantity of lymph

was observed to run from the lymphatics of the scalded leg, while on the sound side no more escaped than before, proving conclusively the influence of the vascular lesion in causing increased transudation.

These facts fully explain the varying conditions under which œdemas occur. Thus the complete anuria, lasting days, which is not infrequently seen in hysteria, never gives rise to at least visible œdemas, yet we are forced to the conclusion that much of the fluid otherwise secreted by the kidneys must, in these cases, be retained in the system. Lesions of the vessels evidently do not occur within the anuric period, despite the fact that the excrementitious matters must be retained as well as the water.

In renal disease it is the rule not to have œdemas and anasarcas till late in the course of the malady, that is, not until after the hydræmia has existed for some time, and the whole system has fallen into a state of malnutrition. This state of malnutrition is brought about by the excrementitious materials, especially urea, circulating in abnormal quantities in the blood, and leading to functional derangements of all kinds, but especially of the alimentary organs, which, hindered in their offices, are no longer able to pour into the circulation the albumins required for the sustenance of the body. (Thus we have a triple cause for hydræmia: retention of water, escape of albumin by the kidneys, and decreased supply from food, and each condition serving but to intensify the others.) In this general malnutrition the vessels of course participate, the hydræmia injuring their walls, and increasing abnormally their permeability. It is consequently only in the later stages of chronic nephritis, when such considerable portions of the renal tissue have become involved as to cause the retention of large amounts of both urea and water, that transudations into the tissues and cavities of the body are observed.

In acute parenchymatous nephritis following scarlet fever, however, the sudden œdema, often indeed preceding the evidences of renal disease obtainable from the urine, forms a very striking feature. Cohnheim calls attention to the fact that its sudden appearance and general distribution may be ascribed, not so much to the kidney lesion as to the injury done the cutaneous vessels by the scarlatinal dermatitis, thus sustaining the idea that œdema is due to vascular lesion. This view is further supported by the fact that the cutaneous œdema is distributed generally over the body, and that effusion into serous cavities occurs usually only when the œdema of the skin has become very marked.

It has always seemed to me, too, that the œdemas produced by taking arsenic can be more rationally explained by supposing them due to a direct lesion of the cutaneous vessels, rather than by their having a causal connection with the slight albuminuria which is frequently, though not always, present. That the cutaneous vessels are often quite seriously affected, is shown by the tendency for slight, often unperceived, bruises and other injuries, to cause ecchymoses, and by the liability to hæmorrhage from the nose and mucous membrane of the mouth. The arsenical albuminuria is too slight to lead to hydræmia; besides, during its very occurrence patients may greatly improve in general health and assume a blooming appearance, which would scarcely occur if the blood were being impoverished.

The so-called cachectic œdemas, seen in the course of debility, from any source whatever, and unassociated with albuminuria, are due essentially to the same fundamental cause that produces renal dropsy.

We find them in chronic anæmias, in carcinomatosis, in chronic suppurations, and many other conditions associated with a state of prolonged malnutrition of the body. In these cases the degree of transudation is never so great as in renal or cardiac dropsy, being generally confined to slight swelling about the ankles in the daytime, and puffiness under the eyes on rising in the morning. The reason for this is that the loss of albumin is trifling when compared to that which occurs in nephritis, nor is there that renal insufficiency which causes a retention, within the circulation, of the waste products of metabolism as well as of water, and consequently, the vessels being less injuriously affected, a far smaller degree of hydræmia is produced.

There would now remain for us to consider the changes occurring as the result of those qualitative alterations of the blood which involve its corpuscular elements. As these, however, will be described by others in detail under Chlorosis, Leucocythæmia, Idiopathic Anæmia, and other special headings, it will not be necessary to consider them here.

[NOTE.—The writer desires hereby to acknowledge his indebtedness to Cohnheim's *Vorlesungen über allgemeine Pathologie*, 2d edition, 1883, for much of the above material.]

Walter Mendelson.

ANÆMIA, IDIOPATHIC. (Synonyms: *Progressive perniziöse Anämie*, Biermer; *Essentielle Anämie*, Lebert; *Essentielle maligne* or *Essentielle febrile Anämie*, Immermann; *Perniziöse Anämie*, Quincke; *Anémie progressive*, Lepine.)

DEFINITION.—Idiopathic anæmia is a grave form of anæmia which develops independently of any known causal organic lesion. It is characterized by a reduction in the total amount of the blood and by a change in its physical, anatomical, and chemical characters. The blood is thin and pale and not coagulable. The red corpuscles are lessened in number and changed in size and shape. The occurrence generally of a maintenance of adipose tissue is peculiar, while, secondarily, fatty degeneration of the heart is almost always found. It is distinguished, clinically, by the symptoms of grave anæmia, often by an irregular fever, retinal hæmorrhages, and hæmorrhages underneath the skin, and from mucous membranes. Its course is usually progressive, its termination fatal, its duration from seven weeks to from two to three years. Complications are rare; death is due to exhaustion, to syncope, to œdema of the lungs, or to cerebral complications.

HISTORY PREVIOUS TO 1872.—The publication by Biermer, in 1872, of a series of cases of this disease, claiming for himself its first recognition, aroused the lethal energies of the English, so that since then they have justly and successfully shown that to one of their countrymen is due the credit of having identified it long before that time. Addison certainly had observed and taught the clinical course of the disease, and made inquiries into its pathology. He clearly established that idiopathic anæmia was an independent affection, and so impressed it upon his co-laborers and students that ever since then it "has not been lost sight of at Guy's." The wards of that hospital have furnished most of the cases for English memoirs, and its reports contain many observations and discussions on it. Prior to Addison, Coombe,[1] Marshall Hall,[2] and Barclay[3] reported isolated cases of fatal anæmia. Since then, and before Biermer's publication, Wilks,[4] Bristowe,[5] Leared,[6] and Habershon,[7] made contributions to our knowledge of the disease. The labors of Taylor,* of Pye-Smith,* of Mackenzie,* and others, have clearly proven these facts of English priority. Professor Eichhorst,* in his elaborate monograph, admits these claims, while Pepper,* in the United States, was one of the earliest to point out the credit due Addison. In the meantime, the French, through Lepine,* presented their claims of priority in the early recognition of the disease. He justly admits the valuable work of Addison and his followers, but says that Andral[8] was the earliest observer, that Piorry,[9] Cazenave,[10] and Perroud[11] had recognized the affection, the latter detailing four cases, with autopsies. A dissenting voice arose among the Germans. Lebert* claimed that he had, in separate papers, described this disease, but the evidence from them shows that he had seen one case, and that his others were cases of chlorosis or puerperal anæmia. Lately, it has been found that American physicians can enter claims of priority for one of their countrymen.[12] Channing* described cases of fatal anæmia in connection with, and independent of, pregnancy as early as 1832. Not only was he himself, but many of his associates also, perfectly familiar with it.

* See Bibliography.

HISTORY SINCE 1872.—The time of the publication of Biermer's * essay on "Progressive Pernicious Anæmia" makes an epoch in the history of this strange disease. He not only embodied in his essay as faithful a portrayal of the disease as Addison and others had done, but added to it more accurate accounts of the blood-changes and the occurrence of retinal hæmorrhages. Moreover, he so impressed the medical world with the important results of his observations that since then, instead of knowledge being local and confined mostly to England concerning it, it has become universal, and multitudes of observations have been in a short time added to previous comparatively scanty labors. In 1874 Immermann,* in 1875 Zenker,* and in 1876 Quincke,* made valuable contributions to its study, while in 1877 important and elaborate monographs, by Müller * and Eichhorst * respectively, appeared. Since then German literature has been rich in observations of isolated cases. From England Pye-Smith,* in 1875, published two cases in the *Deutsches Archiv*, and since then, among others of his countrymen, Bramwell,* Mackenzie,* Finney,* and Coupland * have written interesting and important articles. In America Pepper,* Howard,* Osler,* and others, have made valuable observations. From a study of its history we find that a true conception of idiopathic anæmia has only been arrived at through the combined labors of many observers. Thus Addison clearly defined the limitations of the disease, Wilks first observed some of the blood-changes, Biermer described the retinal hæmorrhage. Then Immermann showed the relations and importance of the febrile process, Quincke contributed to the microscopical appearances of the blood, showed the extreme deficiency in hæmoglobin and the occurrence of siderosis, while about the same time Eichhorst published the blood-changes which he considered pathognomonic, Pepper first demonstrated the possible relationship of this disease to an affection of the bone-marrow. His work was corroborated by Scheby-Buch, Cohnheim, and Osler. The latter author has also made valuable investigations on the appearances of the blood. Professor Howard was the first to consider the relations of this form of anæmia to other forms, and to show that any form of anæmia may become pernicious. Granting the credit due these eminent observers for the work they have done, it is not detracting from it to say that about the year 1830 a coterie of physicians in and about Boston were well aware of the occurrence of fatal anæmia without assignable cause; that they had discussed its nature and clinical course in their societies, and had published their observations to the world.

NAME.—Idiopathic anæmia and essential anæmia are the least objectionable names given to this affection. They both define it as a primary individual disease, and do not commit us to any pathology. Hobson [13] thinks that the use of "idiopathic" hints at the ætiology and leaves the mind in a state of expectancy. He prefers "pernicious," because it expresses an absolute circumstance of the disease. The use of the latter term, and also the use of "progressive," with or without "pernicious," are faulty, because they express clinical features which often do not belong to the disease. The same objection may be urged against "essential febrile anæmia." "Idiopathic" is preferable to "essential" only because of its historical value; the name having been given to the disease by Addison. Otherwise the latter term would be used.

RELATION TO OTHER FORMS OF ANÆMIA.—The definition given above, it is hoped, imparts to the reader a clear idea of the scope of idiopathic anæmia as it will be treated in this article. It has been described by authors as a primary independent affection (Addison, Wilks, Pye-Smith, Biermer, and others) in accordance with the definition given above; as an affection which includes pernicious varieties of the simple and symptomatic anæmias (Eichhorst, Quincke, Howard); as an affection which may be simple and pernicious, chlorosis being an example of simple idiopathic anæmia (Coupland); and finally, as a cytogenic anæmia due to hyperplasia of the bone-marrow (Pepper, Scheby-Buch, Osler, Cohnheim). Lepine is more comprehensive in his ideas of idiopathic anæmia, dividing it into three classes: the first class depends on lesions of the cytogenic organs (anémie progressive, splénique et médullaire); the second on gastro-intestinal disorders (a. gastro-intestinale); the third on pregnancy (a. gravidique). Our knowledge of the blood is involved in so much obscurity that it is impossible to subdivide by fast lines its pathological changes. Only broad distinctions can be used in making subdivisions. There is no doubt that cases occur on the border-land of classes that resemble one another so closely as to scarcely admit of separation. Witness the striking sameness of the chemical and microscopical characters of the blood in fatal chlorosis and idiopathic anæmia, or the progress of an essential anæmia to a leukæmia. It is very easy to show a close resemblance of the various anæmias, clinically; the general appearances and symptoms, the cardiac, cerebral, gastro-intestinal, and pulmonary symptoms are more or less similar, differing more in degree than in kind. (See Diagnosis.) Any attempts, therefore, to define a relationship must be temporary, and revised as our knowledge grows. Moreover, such discussion will probably be found in the preceding article. The question will be recurred to in the section on Pathology, but it is well, for the elucidation of what follows, to state briefly the restricted sense which will be applied to the disease.

1. *Relation to Cytogenic Anæmias.*—In a small proportion of cases lesions of the bone-marrow were found in cases presenting the clinical features of idiopathic anæmia. It has not been proven that the condition stood as cause or effect, though the weight of evidence appears to incline to the latter. (See Pathology.) It cannot therefore be a pseudo-leukæmia.

2. *Relation to Chlorosis.*—Coupland's ideas of the relationships of the various anæmias are well supported by himself with arguments and facts. His classification is as follows: Primary or idiopathic anæmia—simple, pernicious; secondary or symptomatic—simple, pernicious. Chlorosis, he thinks, is an example of simple idiopathic anæmia, and that it can be separated, if at all, only with difficulty from the idiopathic anæmia of Addison. They differ, not greatly he says, in age and sex of patients affected; the microscopical appearances and chemical changes of the blood are almost the same, if not identical; in the main, the clinical features and post-mortem changes of the two agree.* There is striking truth in the relationship, but the practitioner's conception of the diseases born of actual contact is far different. He finds a difference in cause, a difference in symptoms (marked nervous phenomena and constipation, etc., in chlorosis), and a difference in treatment. For the termination of the one he is filled with hope; for the other, with despair. The distinction may be broad, but it is none the less real, and in the lack of positivism should be excepted.

3. *Relation to Secondary or Symptomatic Anæmia.*—Eichhorst would have us believe that there is a sufficiently close relationship between malignant symptomatic anæmia and idiopathic anæmia to warrant establishing a pathology of fatal anæmia from the combined features of each. There is no existence of sufficiently near kinship either in cause, clinical course, or effects of treatment, scarcely in anatomical characters, between the two forms of anæmia, to permit this. It is one of the evil results of the application of the term "pernicious" to the anæmia of Addison.

Idiopathic anæmia will, therefore, not be considered in these pages either as a myelogenous leukæmia, as a grave form of chlorosis, as an affection allied to the pernicious form of symptomatic anæmia, or as a disease embracing all these groups. It will be described as an entity, capable of clinical and anatomical diagnosis, the course of which we are able to prognosticate. It is worthy, on account of its actuality, of a place in nosology. It is not to be forgotten that the restriction may

* See Bibliography.

* The striking feature of chlorosis is a greater deficiency of the hæmoglobin in the blood in proportion to the diminution of red corpuscles—the individual corpuscle contains less hæmoglobin than normal. Such a condition does not obtain in idiopathic anæmias.

be effaced with further knowledge of the physiology and pathology of the blood.

MORBID ANATOMY.—The appearance of the body after death is characteristic. The entire surface indicates an absence of blood—extreme pallor of the face, the extremities, the trunk, and the external mucous membranes, so that, if not for the dirty-yellow or straw-colored appearance of the face and hands, a sudden profuse hæmorrhage might be considered the cause of death. On the extremities, the back of the hands, and the dorsum of the feet, the ankles and wrists, minute extravasations of blood are often seen. They vary from the size of a pin's head to that of a split pea, and are purple or yellow-red in color. Œdema of the feet and ankles, of the hands and of the face is sometimes seen. The œdema may be limited to the eyelids or may be general. It may vary from this slight amount to a universal anasarca. Wasting of the body is often not marked, in fact this absence of emaciation was thought in the early history of the disease to be the rule, but a few well-authenticated cases are recorded in which it was present. The presence of fat, for it is the adipose and not so much the muscular tissue that remains, is more noticeable in the abdominal walls than in any other region of the body. It is said that rigor mortis does not develop early after death.

On section, the most striking feature is the bloodlessness of all the tissues. A large proportion of cases exhibit the presence of subcutaneous œdema in the parts indicated above, while œdema of the lungs and meninges is common; passive effusions into the serous cavities occur less frequently. The effusions are generally small in amount, and hence are not appreciated during life; considerable ascites, hydrothorax of one side, or hydropericardium have been but rarely seen. The exuded serum is of a deeper yellow color than usual. The preservation of adipose tissue is remarkable, not only in amount, but also in appearance. The subcutaneous and subserous accumulations remain, and the appendices epiploicæ are well preserved. The color of the fat is bright, or sulphur-yellow, due, Lepine suggests, probably to ferrous sulphide. The muscles are generally firm and red, though the bulk is reduced. Fatty degeneration of the diaphragm and the abdominal muscles has been observed.

In addition to the absence of emaciation and the extreme bloodlessness of the body, one of the characteristics of idiopathic anæmia is the occurrence of small hæmorrhages. These are seen in the skin as minute extravasations, they are found underneath the serous membranes—the pericardium, the peritoneum, and rarely the pleura—as minute points and specks; under the endothelium of the blood-vessels they have also been seen. They frequently occur in the brain-substance as capillary hæmorrhages. Similar hæmorrhages are found in the mucous membrane of the œsophagus, the stomach, and the intestines, in the lungs and upper air-passages, and in the bladder. The most frequent seat of these extravasations, however, is the retina. These hæmorrhages are due to rupture of capillaries on account of the diseased state of their walls, or to diapedesis.

The last general change that is often seen on section of the body is the occurrence of a dark-gray staining of the organs. This has been proven to be due to an excess of iron in the tissues. Rosenstein [14] found .5187 per cent. of iron in the liver, .2275 per cent. in the spleen, .0422 per cent. in the kidneys. Quincke found .6 per cent. metallic iron in the liver and .32 per cent. in the kidneys in one case. In another case the liver contained 2.1 per cent. The iron was seen in the liver-cells as small granules. Iron has also been found in the tissue of the lungs and of the pancreas, and in the peritoneum. Purser [15] found the dried kidneys to yield .0352 per cent. of iron. This increase of iron goes hand in hand with diminution of hæmoglobin. Some of these cases were taking iron at the time, which renders any conclusions concerning them doubtful. Oidtman (quoted by Rosenstein) found, on analysis, the healthy liver to contain .08 per cent. and the spleen .15 per cent. of iron.

The blood, extremely small in amount, is collected in the heart and larger venous trunks. The small amount of blood in the body can be appreciated during life by attempts to secure some for examination. A deep thrust of a pin in an artificially congested finger, or even an incision, is required to obtain a few drops. It is thin and watery, stains the hands like nitric acid,[16] or looks like muscle-washings or weak coffee. Coagula are rarely found in the cavities of the heart and the vessels. If present, they are soft, friable, and pale- or light-brown. The blood removed from the body to a test-tube, on standing, remains uncoagulated for a long time, although a deposit of the corpuscular elements takes place. The specific gravity of the blood has been found to be as low as 1.030.

On microscopical examinations, the red blood-corpuscles are found to be much less in number than normal, and changed in color, in size, and in shape. Few, if any, changes take place in the white corpuscles. Litten [17] recorded a case of pernicious anæmia which passed into leukæmia. The number of the white cells is normal. They are, however, relatively more numerous. In some few cases they are recorded as being larger than normal and less granular. They do not show any retardation of amœboid movement on the warm stage (Pye-Smith, Gardner and Osler).*

Davy and Mackern[18] found in a case two classes of white corpuscles, viz., large and small ones. The former resembled the normal, and showed amœboid movement; the latter were abundantly granular, appearing like free nuclei, and showed no amœboid movement.

RED CORPUSCLES.—1. *Number; Oligocythæmia.*—The diminution in number of the red corpuscles sometimes goes on to an extreme degree. Quincke [19] records a case in which the number fell to 143,000 per cubic millimetre.† Cases are said to have recovered when the red cells were reduced to 360,000 (Worm Müller), while the above case also recovered. The smallest number the writer has seen in any case which subsequently recovered, was 570,000. The amount of reduction in fatal cases averages from 400,000 to 1,000,000 corpuscles per cubic millimetre. The reduction takes place with great rapidity very often. Thus, in one of Lepine's cases, in ten days the number fell to 378,750. The increase in number is not so rapid when improvement takes place. In the case of Quincke, mentioned above, the cells increased in ten weeks from 143,000 to 1,234,000 per cubic millimetre. One of the writer's cases arose from 570,000 to 1,600,000 in about nine months, followed by gradual recovery.

2. *Changes in Size and Shape.*—The red cells are pronounced as increased in size, as normal, and as very small. The large-sized corpuscles occur less frequently than the other forms. Osler [20] found some of them to measure as much as $\frac{1}{1700}$ and $\frac{1}{1800}$ of an inch in diameter. The normal diameter of a red corpuscle is $\frac{1}{3500}$ of an inch, or from 6 to 8.8 micro-millimetres (Hayem). Mackenzie* says, in some cases of anæmia they are found increased to ten or twelve, or even fourteen micro-millimetres. Eichhorst saw some that were 9.5 μ in diameter. The large red corpuscles have lost their bi-concave form, are flat, oval, and tailed. The corpuscles that are normal in size present the most varied shapes. They, too, have lost their normal disk-shape, and are pear-shaped, spherical, oblong, irregular, bowl-shaped, oval, egg-shaped, tailed. An appearance of nucleation of the red corpuscles has been described and figured by Bramwell, by Mackern and Davy, and by Finney. The nucleus was seen by them at the side of the red corpuscle. Mackern and Davy attributed it to the separation of the hæmoglobin from the stroma. Bramwell accepts their explanation. Finney found it to be due to the deposit of a small yellow corpuscle on a large pale one. Crenation of the red corpuscles is an almost constant phenomenon, probably due to the action of air, or of the various solutions employed in the examination. It is not a special characteristic of the blood in this disease. The changes of shape Mackern and Davy believe to be due to the fact

* See Bibliography.

† The number of corpuscles per cubic millimetre can be expressed in percentage or per hæmic unit, as suggested by Gowers.

Anæmia.

that the stroma is abnormally soft. The presence of very small corpuscles, known as microcytes, was considered by Eichhorst and others as pathognomonic. Rosenstein,[21] Grainger Stewart,[22] Bradford,[23] and Lepine* failed to find them in well-observed cases. They look not unlike globules of oil, are deeper in color than the large-sized corpuscles, and range in diameter from $\frac{1}{7000}$ to $\frac{1}{9000}$ of an inch (Osler), or 2.2 μ. They are more frequently present than wanting. The changes in shape of the corpuscles more strictly occur in pernicious anæmia than in any other affections, and are diagnostic, almost pathognomonic (Osler, Bradbury, Quincke, Purser). Finally, it is characteristic of the corpuscles not to form rouleaux, but often to gather in clusters. In those cases in which this piling together was noted, the rouleaux were few in number and small in size. The alterations in the shape and size of the corpuscles have been termed pæcilocytosis by Quincke, microcytosis by others, and anacro- or micro-cythæmia.

3. *Color; Achroicythæmia.*—The color of the blood, as it appears to the naked eye, has been mentioned. By the microscope it is seen that the large and medium-sized red corpuscles are much paler than normal. The microcytes are deeper in color. This change in color is due to a deficiency in hæmoglobin. This deficiency is in proportion to the destruction of the corpuscles. It is determined by the hæmochromometer devised by Gowers or by Quincke. Coupland,[24] Mackenzie, and others, believe there is no relation between the reduction of the cells and their richness in hæmoglobin. According to Quinquand,[25] there are 125 grammes of hæmoglobin in 1,000 grammes of normal human blood. A reduction to 26.5 grammes, or about one-fifth, he says, was invariably fatal. The deficiency in hæmoglobin is expressed by percentages when estimated with a hæmoglobinometer. By it the presence of from 18 to 35 per cent. of hæmoglobin has been found. Quincke found it to be one-eighth, one-tenth, one-fifteenth to one-thirty-fifth, respectively, of the normal in four cases. Leichtenstern says the diminution is greater than in any disease—far greater than in chlorosis.

In addition to the change in the size, shape, and color of the red corpuscles, other changes are found worthy of mention, the import of which has not been determined. They are: 1. The presence of large globular nucleated red corpuscles (Osler and Cohnheim). In these cases the marrow of the bones was diseased. 2. Cells containing red corpuscles have been described as present by Riese.[26] They occur normally in the red marrow and spleen, but to excess in idiopathic anæmia.[27] 3. Max Schultze's granular masses were so abundant in one of Quincke's cases as to render the serum cloudy. Osler noted their absence in many cases.

None of the above elements were seen in any of the cases the writer examined.[28] Otherwise the account of the blood tallies well with his experience. The following résumé succinctly shows the blood-changes: Case I. Autopsy: Amount small, color like weak coffee, clots soft. In pulmonary vein, clot black; in aorta and pulmonary artery, soft yellow clot; in vena cava, soft red brown clots, with black specks intermingled. The presence of the black motes in the red clots was peculiar. It has not been noted in the autopsy of any other case, and it is to be regretted that their nature was not determined. The ventricles contained semifluid, red-brown clots. Blood microscopically: Case I., red cells small, irregular, like drops of oil, 715,000 per cubic millimetre, 15,000 white per cubic millimetre. Case II., red cells small, 2,210,000 per cubic millimetre, first examination. Blood thin and pale. Second examination, red corpuscles, 1,000,000 per cubic millimetre—1 white to 40 red. Recovery. Case III. Blood thin, watery, difficult to secure. Red corpuscles small, 570,000 per cubic millimetre; gradual increase to 1,600,000.

A chemical examination of the blood of idiopathic anæmia has not been made, no doubt on account of the difficulty of securing a sufficient amount of the liquid. The writer had the blood of a case which was under his care (Case I., *supra*) examined by Dr. John Marshall, the very efficient demonstrator of chemistry in the University of Pennsylvania. The result of the analysis is placed side by side with the composition of the blood of females as determined by Becquerel and Rodier:

FEMALE, IDIOPATHIC ANÆMIA.	In 1,000 parts.	FEMALES, HEALTHY.	In 1,000 parts.
Water	800.1950	Water	791.10
Fibrin	4.9600	Fibrin	2.20
Albumen	59.7000	Albumen	70.50
Inorganic salts	7.2410	Extractive matter, Fatty matter, Salts, including iron,	9.01
Iron	.1871		
Fats and Extractives	2.1800		
Blood-corpuscles	125.5369	Blood-corpuscles	127.00

Normally the inorganic salts, including the iron, equal 7.15 parts in 1,000; so if we deduct that figure from 9.01, we have 1.86 part, representing the amount of fats and extractives found. By this analysis it is seen that these constituents are increased. Inorganic salts and iron are represented by 7.15 parts; 54 parts of iron are found in health; the difference, 6.60 parts, is the amount of salts in health. The salts, therefore, are increased by .64 part. Iron is reduced about two-thirds, and this is what one would expect (.54 to .18+). The albumen has been said to be reduced in idiopathic anæmia. We have not seen a definite analysis. The result of our analysis shows a lessening of about 11 parts to the 1,000. The increase in the amount of fibrin is not what would be expected, and yet any one who knows the care and skill of Dr. Marshall will not doubt his work. A study of the analyses quoted by Coupland shows it to be an extremely variable factor.

CYTOGENIC ORGANS.—The spleen is recorded as variable in size—from shrivelled up or very small, through all gradations to enlarged, weighing in one instance 453.5 grammes. It generally is more charged with blood than any other organ. It is not pulpy, but soft and congested, and on microscopic examination there is found an absence of pathological change, save an excess of fibrous tissue in a few cases. The lymphatic glands are usually normal. In a few instances the lymphatic glands of the mesentery have been recorded as enlarged, due, as Pye-Smith suggests, to a previous diarrhœa. In one case the lumbar lymphatic glands were enlarged. The marrow of the bones is said to undergo a primary hyperplasia in this disease, thus defining it to be a pseudo-myelogenetic leukæmia. The appearances described by many observers correspond in the main. The marrow is red or violet colored, and is soft or pultaceous. Its fatty appearance has disappeared, and under the microscope the fat is seen to be replaced by abundant lymphoid elements, the normal marrow cells, large and small in size; by colored corpuscles non-nucleated, varying in size, the larger ones being of abnormal shape; by nucleated red corpuscles of various size and considerable number; by cells containing red blood-corpuscles. In addition to this, the myeloplaxes, which belong normally in this region, are generally found, though Purser[29] noted their absence. These changes were found in the marrow of the shafts of the long bones as well as in that of the flat bones. In the larger number of cases the marrow of the bone was not changed to fœtal marrow, but had the appearance of normal adult marrow. In no instance has the cytogenetic tissue of the liver or intestines been reported as hypertrophied.

CIRCULATORY APPARATUS.—More marked pathological changes take place in this apparatus than in any other. The heart is normal in size or dilated; the muscular tissue soft, flabby, pale in color; often the cavities are empty, or they contain soft brown, or fawn-colored clots. To the naked eye the appearances of fatty degeneration are most striking. There are some cases in which this change was not seen; when present, it is most marked on the musculi papillares and columnæ carneæ, and appears as yellow dots, "zigzag striations," or "tabby-mottling." The subpericardial fat generally is abundant (Eichhorst). The ventricles are more degenerated than the auricles, it is said, although the writer has observed in two cases an extreme degree of wasting of muscular fibre in the

* See Bibliography.

auricles. So marked was it that they transmitted light, the fasciculi of the muscle could be separated, and the endo- and peri-cardium seemed to make up the auricular wall. The left heart is more markedly degenerated than the right. In one case of the writer the converse was the case. Wilks first described the occurrence of fatty heart. Microscopical examination reveals the destruction of muscle striæ and their replacement by fat. The pericardial sac contains an excess of serum very often, rarely any blood. Ecchymoses, however, are quite common underneath this membrane as well as the endocardium. The valves are normal, or superficial specks of atheroma may be seen on them. Similar changes are found in the intima of the aorta to a slight degree. The capillaries have been studied carefully, and Eichhorst says minute aneurisms may be seen; Mantz describes minute varicose dilatations in the retina, Charcot in the brain. Nykamp [30] opposes these views, and attributes the hæmorrhages to diapedesis. Rupture of the capillaries has been observed. Osler [31] saw the small vessels and capillaries of mesenteric glands studded with fat grains. The arrested development of the heart and aorta and the anomalous distribution of the blood-vessels, said by Virchow to be present in chlorosis, was seen in one of Müller's cases. The aorta at its origin was one centimetre in diameter, and admitted the little finger at the seat of origin of the cœliac axis in one of the writer's cases. The heart was not small, however.[32]

Respiratory Organs.—Secondarily to the failure of the heart an œdema or hypostasis of the lungs often occurs, and this is in a large number of cases the only morbid condition of these organs. Generally the lungs are extremely anæmic. Sometimes the remains of an old phthisis or an emphysema are seen; very rarely are they the seat of a croupous pneumonia. Hæmorrhages underneath the bronchial mucous membrane are found, sometimes a bronchitis; pallor of the membrane is noticeable. The pleura is healthy, or the seat of subserous ecchymoses; one cavity may contain serum in a large amount, mingled sometimes with threads of fibrin, or both cavities may contain small amounts of serum. The effusion is sanguinolent sometimes.

Organs of Digestion.—The mucous membrane of the gastro-intestinal tract is pale, often also œdematous. Very frequently, however, submucous hæmorrhages and hæmorrhagic erosions are seen. They have been noted in the mouth, œsophagus, stomach, intestines, and biliary passages. In the stomach, Fenwick,[33] Ponfick, and Habershon have found a fatty degeneration of the tubular glands. A muco-gastritis has also been recorded. Intestinal catarrh, chronic follicular enteritis, with enlargement of the follicles and agminated glands has been recorded. Dysenteric inflammation of the intestines was observed by Quincke in the late stages of one case.

The changes in the mesenteric glands have been previously recorded, as likewise those, to a certain extent, in the liver. That organ is very often anæmic and generally fatty. This fatty degeneration of the liver was specially described early in the history of the disease by Wilks.[34] Perroud [35] thought the hepatic change was primary, the blood-change secondary; the fatty degeneration interfering with the formation of blood. The degeneration is seen in the liver-cells, large fat-drops rendering the nuclei difficult of detection. Deposits of pigment have been described by Eichhorst and Quincke in the hepatic cells, the blood-vessels, and the interstitial tissue, causing the iron-gray staining referred to previously. Minute extravasations of blood have been seen. Rarely the liver is congested. The size of the organ varies; generally normal, it has been recorded as lessened and also as increased. The surface of the liver is usually smooth and normal; a perihepatitis has been recorded by Müller.

The liver tissue is smooth and compact on section, and the acini are well defined; a nutmeg appearance has been noted in a few instances. The biliary passages are normal or thin, mucous membrane extremely pale. Suppuration of the gall-bladder was present in one of Pepper's cases. The gall-bladder is generally full of bile.

On micro-chemical examination, in addition to the presence of iron, Lebert found leucin and tyrosin in abundance in the liver as well as in the pancreas, lungs, kidneys, and spleen.

The pancreas is normal usually. It is sometimes enlarged, and Eichhorst and Quincke found extravasated blood in the interacinous tissue. Huguenin observed fatty degeneration of the glandular epithelium.

Renal and Genital Organs.—Ecchymoses have been observed under the capsule of the kidney, which is readily removed in most cases. The organs are pale and firm on section; often the appearance of fatty change is seen. Microscopical examination reveals the presence of fatty change in the epithelium of the tubules. The remaining portions of the urinary apparatus are normal, save the occasional presence of submucous hæmorrhage.

The suprarenal capsules are normal. Broadbent recorded the occurrence of atrophy of the organ. The microscopical examination of these capsules in the writer's case revealed slight increase of the interstitial tissue, with infiltration of lymphoid elements. The vessels were engorged with blood and small capillary hæmorrhages were seen. Pigmentation and slight fatty infiltration of the cells in the capsule were seen, probably not greater than normal. Granular masses, not unlike colonies of bacteria, were observed.

No changes are found in the sexual organs. Müller noted subinvolution of the uterus in a fatal anæmia following pregnancy.

Nervous System.—The brain and spinal cord may be anæmic, the seat of minute ecchymoses or (within the brain) of large hæmorrhages. The cerebral ventricles contain sometimes an excess of serum or blood. The hæmorrhages are chiefly found in the region of the corona radiata, or on the surface of the cerebrum. The pia mater or the inner surface of the dura is often the seat of ecchymoses. Eichhorst and Müller observed hæmorrhagic pachymeningitis. These authors also have found œdema of the membranes. Microscopically, Eichhorst found no change, save increased pigmentation of the ganglion cells. Schuman ("Diss. Inaug.," Freiburg, 1875) found increase of the nuclei of the cerebral neuroglia. The changes in the vessels have been mentioned.

Since the earliest observations of idiopathic anæmia, the appearances of the sympathetic system were studied. Quickett found the semilunar ganglia in Addison's case to have undergone fatty degeneration. Brigidi found (*Lo Sperimentali*, May, 1878; *London Medical Record*, vi., 430) proliferation of the nuclei, increase of interstitial tissue, and granular pigmentation of the ganglion corpuscles of the solar plexus. Wilks and Pye-Smith found no changes in the semilunar ganglia and surrounding plexuses. The writer found pigmentation of the nerve-cells and along the nerve-fibres, with a slightly granular appearance of the cells. Macroscopically, the ganglia and nerve-filaments were unusually prominent. Sasaki (*Virch. Archiv*, vol. xcvi., 1884) found sclerosis of the ganglion cells, destruction of some of them, and homogeneous, hyaline bodies in Auerbach's and Meissner's plexuses in a case of pernicious anæmia of the gastro-intestinal form.

Organs of Special Sense.—*The Eye.*—The occurrence of retinal hæmorrhages during life has called attention to an examination of the fundus of the eye after death. The changes are not different from those found in other diseases, as at times in chronic Bright's disease and in the secondary anæmias. The changes in the vessels causing the hæmorrhages have been previously referred to. Uhlhoff [36] says the hæmorrhages are chiefly limited to the nerve-fibres and internuclear layers, and are situated near the posterior pole, especially around the disk. Varicose hypertrophy of the nerve-fibre affecting the most internal layers and consisting of finely granular masses, spherical or spindle-shaped, was also present. Bettman [37] found on microscopical examination, (1) rupture of the membrana limitans interna; (2) the presence of numerous clusters of varicose nerve-fibres, due to transudation of lymph, producing swelling of these fibres. Optic neuritis has been seen; œdema of the disk and retina has also been observed.

Ætiology.—This is obscure. It is extremely difficult

to reckon the influence of the age, the sex, the habits, and the condition of life as predisposing factors; while our want of knowledge of the pathology of the disease makes it as difficult to determine the exciting cause. In fact all that can be said is that under certain circumstances and influences the disease develops more frequently than under any other, without our being able to give a reason. It is divided about equally between the sexes, according to some (Coupland,* Eichhorst*). Bristowe[38] says it is more frequent in the males. Müller,* Immermann,* and Biermer* give predominance to the female sex. It is found to occur as early as five years,[39] or as late as sixty-eight.

The following table, taken from Pye-Smith's very able article, shows well the relations of age and sex, according to various authors. "Many of the cases are common to all four lists."

	H. Müller.		Coupland.		Eichhorst.		Pye-Smith.
	Male.	Female.	Male.	Female.	Idiop.	Second.	
Under 15....	0	0	1	0	0	1	6
15 to 20....	2	4	2	4	2	1	4
21 to 30....	2	9	8	18	4	17	29
31 to 40....	1	19	9	16	8	22	26
41 to 50....	2	2	19	9	4	16	21
51 to 60....	2	1	14	7	4	9	13
61 to 70....	..	..	3	1	1	1	4

It thus is seen that early adult life is the period of greatest liability. The position in life and occupation seem to have some predisposing influence. In Germany the poorer classes, half-starved ordinary laborers, are more frequently attacked. There are notable exceptions to this in England and this country. Cases have been reported of the wealthy and the well-nourished being affected. Intemperate habits are frequently recorded in the reports. The residents of the country are as often affected as those living in the city, if not oftener. Biermer and Gusserow thought that pregnancy was a powerful predisposing factor, especially too frequent pregnancies and repeated miscarriages. The later pathologists exclude this form of anæmia from the idiopathic, classing it under secondary or puerperal anæmia. In addition to pregnancy, previous diseases, especially those that influence assimilation, have been considered by some as predisposing elements. They are dyspepsia, diarrhœa, and various discharges. The occurrence of the disease with unusual frequency in parts of Switzerland led Immermann to suggest an endemic influence. Though not so frequent in other countries, it is sufficiently so to contradict such statements. Nevertheless, in some localities the disease has been met with more frequently than in other places. One hundred and twenty-nine selected cases, tabulated by Pye-Smith, show well the frequency of occurrence in various countries. The number of cases in each country was distributed as follows: England, 51; Switzerland, 49; Germany, 14; France, 6; United States, 2; Italy, 1. England, with its much greater population, has, recorded against it, but a trifle more than Switzerland. The number he gives for the United States is not correct. Even in as restricted a sense as Pye-Smith used the name, more cases are reported than his analysis would show. Not excluding the possible myelogenetic leukæmia, the writer knows of the occurrence of twenty cases in this city (Philadelphia).† In Canada it appears to be more frequent. Professor Osler informs the writer that he has observed fifteen cases about Montreal. Graham[40] records seven cases in Toronto, and others are reported.

Notwithstanding all the relations above mentioned, not one could be specified as of causal force. Many observers have insisted upon the occurrence of shocks, grief, or anxiety as exciting causes. This is notably the opinion of Lepine, Wilks, and Coupland. Curtin,[41] not knowing of the views of these men, long ago formulated such an idea, and lately has recorded cases which appear to have arisen from such cause. One of the special features of this disease must be emphasized just here, viz., that it is characterized by development without assignable cause.

* See Bibliography.

† Curtin, six cases, including one reported by Pepper; Hutchinson, four cases; Pepper, three cases, excluding Curtin's; Musser, three cases; and Starr, Henry, Hughes, and Bruen, one each. (See Bibliography.)

Symptoms.—The progress of idiopathic anæmia is characterized by three special features—its development without any organic disease to account for the grave symptoms, its insidious development, its progressive and remorseless march to death. Modern pathologists consider the first feature final and absolute: it is not idiopathic anæmia if there has been preceding or concomitant disease sufficient to account for the blood-change. Although the large number of cases do develop gradually and insidiously, yet there are not a few which have occurred quite suddenly, the symptoms arising, after shock or fright, almost immediately. In addition to the exception to the second feature, exceptions may be given to the third. Undoubted cases have been recorded of marked remissions, even temporary suspension of the course of the disease.[42] The rule, however, is a persistence of its course in the larger number of cases. Even though there is an abatement of the symptoms of the disease, some of its symptoms are always marked by remissions, and notably the temperature. The same remarks apply to its fatality; though generally fatal, cures have actually taken place (Bramwell, Finney, Pye-Smith, and others). One of the writer's cases was absolutely cured, the other temporarily improved at least.

The first indication of the patient's illness is the occurrence of debility, pronounced on exertion, with the coincidence of breathlessness and possibly cardiac palpitation. They increase in severity; the complexion is seen to be changed, the bloodlessness of the external parts is made manifest, the appetite is lost, digestion is impaired, hæmorrhages occur, the sight fails, subjective noises in the head are complained of. As the disease progresses, languor becomes more and more decided, dyspnœa is extreme, fainting grows common; while indifference to physical or mental acts, as well as incapacity to perform them, is most noticeable. The "air hunger" which the patient has renders the ebb of life intolerable, and its close is marked by agonizing efforts to carry on respiration. Or the end is marked by a low delirium, passing into somnolence and then fatal coma. At times death takes place suddenly from cardiac failure or from hæmorrhage in the brain. The following brief outline indicates the special symptoms more fully.

External Appearances.—The color of the face is striking—an earthy yellow, yellowish-white, or waxy hue, or a faded-leaf appearance; this color is also seen on the hands. It contrasts strongly with the extreme pallor of the lips, the gums, the tongue, the conjunctivæ. Slight jaundice has been observed, but as Mackenzie points out care must be used in making the observation, as it may be due to the unusual yellow coloring of the subconjunctival fat. Very early the expression is lost, the eyes lose their lustre, the face becomes vacant and ghastly. In the latter stages the face is a little puffy, the eyelids œdematous. This œdema may be seen on the hands and around the ankles. It is due to the hydræmic state of the blood or to the loss of tone of the blood-vessels. It rarely amounts to an anasarca. The hair is soft, turns gray, or has a peculiar lustre as if it had been dyed and is losing the artificial color. Eichhorst notes a loss of hair. The nails are fragile and pale and grow very slowly.

Although there is a flabbiness of the tissues, yet there is generally no wasting of the adipose tissue. This has been well preserved in all but a few of the recorded instances of the disease. Pain and tenderness over the bones have been noted. Eichhorst observed a peculiar cadaveric odor arising from the body a few days before death in a few instances, and from Hutchinson's patient a peculiar musty odor arose.

Hæmorrhages have been cited as peculiar to idiopathic anæmia. They occur subcutaneously, as small purpuric spots about the extremities chiefly. They are seen in other forms of anæmia also; in all of them, more particularly in the retina.

Temperature.—The presence of increased temperature of the body was thought to be pathognomonic by Immermann and others. Some even insisted on its presence, but there are many authentic cases of its absence during the entire disease, while its presence is noted in other forms of anæmia. Generally it occurs at certain periods of the disease, either in what may be termed the middle period or at the end. Thus a case is without fever at first, then there is a rise of temperature for a while, but toward the close, the temperature returns to normal, or may be subnormal. The fever is characterized by frequent remissions, by a moderately low range,* by irregular intermittency, and by fluctuations under slight influences. Biermer and Immermann attribute to it a humoral origin, but any one who argues with Wood,[43] that fever arises from a want of co-ordination of the nerve-centres which regulate the dissipation and production of animal heat, and who appreciates the instability of the nerve-centres in anæmia, on account of the want of blood, need not go further for a theory as to its origin in this disease.

Gastro-intestinal Symptoms.—The mucous membrane of the mouth is pale. The tongue is furred, or it may be clean and smooth; sometimes it is red and raw. Hæmorrhages occur from the gums, and toward the close sordes collect on the teeth, gums, and lips. Salivation has been observed. Gastric symptoms may mark the onset of the disease, and are always present in its course. Loss of appetite is generally present, nausea very frequently occurs, while pain, flatulency, weight and fulness after eating, are prominent. Thirst is not marked. Acidity has not generally been noted, nor has simple gastralgia † often been prominent. The vomiting, especially toward the end of the disease, is so persistent as to lead one to think ulcer or cancer of the stomach may be present. In addition to the food taken, a clear or greenish-yellow acid fluid, mucus, and rarely blood, black in color, are ejected. The vomiting occurs after eating, and is often more like regurgitation of food, and is always attended with nausea. The occurrence of diarrhœa with thin light-colored stools, has often been observed. The diarrhœa is painless. Wilks has seen blood in the stools. On the other hand, the bowels may be regular or confined. Huguenin[44] found leucin and tyrosin in the passages on chemical examination.

Liver and Spleen.—The liver is not generally affected. Rarely it has been recorded as enlarged. The spleen is also wanting in change, though it is slightly enlarged. This enlargement is not great, and can scarcely be demonstrated during life.

Cardio-vascular Symptoms.—The patient complains of palpitation on exertion at first; later palpitation occurs even at rest. The action of the heart is extremely feeble and at times rapid. The least excitement increases the palpitation and tendency to fainting. Cardiac pain is sometimes present. On physical examination the apex beat is found lower than normal, the impulse feeble and diffused. Sometimes the area of dulness is increased, this increase being due, in the later stage of the disease, to dilatation of the heart, or to retraction of the lungs (Quincke). The first sound is extremely feeble, the second clear and bell-like, but not accentuated. Systolic murmurs, pulmonary and aortic chiefly, mitral and tricuspid, are almost always heard, loud and distinct. The occurrence of a diastolic murmur has been noted in a few instances. These murmurs are due to the fluid state of the blood, and possibly to a regurgitation of the blood through incompetent valves. The papillary muscles are so highly degenerated as certainly to interfere with normal valve closure.

A loud hum is heard in the jugular vein. In the carotid arteries a systolic bruit is heard. Such a murmur may be heard in more distant vessels also. The carotids pulsate at times, the veins are large and full, and have been seen to pulsate. The pulse is feeble and compressible, dicrotic, at times irregular and quite rapid. The cardiac symptoms and physical signs of this form are similar to the same symptoms of the other forms of anæmia, while the mechanism of the production of murmurs is the same. The latter, however, are much more intense than in simple anæmia.

Respiratory Symptoms.—The occurrence of dyspnœa is noted early in the disease, at first on exertion only; it becomes constant, and toward the close of life the sufferings from it are extreme. The dyspnœa occurs independently of any organic disease, and is due to the destruction of red corpuscles and the lessened supply of hæmoglobin. Rarely is a hydrothorax found during life, and the same may be said of any organic disease of the lungs or pleura. Pneumonia occurs in a few instances as a complication. Hæmorrhages from the nose are frequent; often the source of bleeding is in the lungs. A Stokes-Cheyne respiration is sometimes present, probably due to the fatty heart or to cerebral complications. Late in the disease œdema of the lungs, or even hypostatic congestion, is liable to occur.

Genito-urinary Symptoms.—These are few; it may be said, in fact, no complaints are made by the patient of renal symptoms. There are no lumbar pains, and there is no painful or increased frequency of micturition. The urine is clear or dark in color, acid in reaction, varies in specific gravity from 1.010 to 1.020, being usually below 1.015, and is normal in amount. The amount depends on the occurrence of vomiting or diarrhœa, being lessened when these conditions are present. Although the daily amount is about the normal average, cases have been reported where the amount was increased from 2,000 to 3,500 C.c. daily (Immermann); in some instances the amount was reduced 800 C.c. (Müller). Müller found the urea, as a result of his analysis, lessened to from 12 to 13 Gm. daily, the chlorides reduced, uric acid relatively increased, and the amount of creatinin diminished *pari passu* with the urea. He, with Huguenin, found distinct indican reaction due to the inanition common to the disease (Senator).

Eichhorst's observations and analyses corresponded closely with the facts above noted. The urine in the fatal case of Mrs. M., under the care of the writer, yielded the following results on analysis: Amount in twenty-four hours, 1,500 C.c.; specific gravity, 1.014; urea, 2.3 per cent.; uric acid, .087 per cent.; sodium chlor., 12 per cent.; phosphoric acid, .13 per cent. On standing there was scarcely any deposit. This deposit was seen to be composed of amorphous phosphates and some few leucocytes and epithelium. A second case yielded the following: Urea, 1.5 per cent.; uric acid, .017 per cent.; chlor. sod., .565 per cent.; phosphoric acid, .146 per cent. Apart from the change in the normal constituents of the urine, few if any pathological products are found. In the later stages of the disease albumen is sometimes observed. It is present in small amount, and its occurrence corresponds with that of some general depression or temporary cardiac embarrassment. Quincke observed a large amount of albumen, in one instance, as did also Müller. The kidneys were highly fatty in the latter observer's case. With the albuminuria that precedes death, there are found hyaline casts (Müller, op. cit., obs. xlviii., p. 239).

Sugar has never been detected in the urine in patients with idiopathic anæmia. Müller found leucin and tyrosin. Blood from hæmorrhages into the pelvis of the kidney or from the bladder has been seen. Reynolds, in a careful analysis of the urine of one of Dr. Finney's patients, found an increase in the percentage of iron, both when the patient was taking the drug and when it had been discontinued some time. In the first instance he found .7485 grain of iron, and in the second .308 grain in 72 ounces of urine.

The genital organs in the male or female are not especially influenced in the course of the disease. In the female the menstruation may be more profuse than normal or recur too frequently, and even menorrhagia may develop. The pregnant female will abort, or premature labor will take place.

Nervous System and Special Senses.—Headache and giddiness, with subjective noises in the head and ears and

* Cases are recorded in which the temperature rose to 106° (Quincke), and a range of 103° to 104° is quite common.

† Epigastric pain and tenderness were extreme in Purser's case.

subjective flashes of light, develop in proportion as the anæmia grows profound. There are but few cases in which these symptoms are absent. They are due to the hydræmic condition of the blood. As the disease progresses loss of memory is seen ; an apathy and sluggishness of action of the cerebral faculties is quite remarkable, and low wandering delirium gradually advancing to stupor and coma often mark the close of the disease. Rarely convulsions occur, while in some instances paralyses have taken place some time before death, chiefly limited to monoplegias. These cerebral symptoms are due to hæmorrhages within the brain substance and in the membranes, and to œdema of the brain.

One of the symptoms on which Biermer had laid much stress was the ophthalmoscopic appearance of the fundus of the eye. By him, and for a time by others, actual hæmorrhages were thought to be constant attendants of this disease. It has been shown, however, that they are present in other cachexiæ, and may be absent in this. In two of the writer's cases they were present, in one absent. Their presence does not imply a fatal termination, nor their absence a favorable one (Coupland). In some instances they were so large as to impair vision and even to cause blindness ; generally they are small. They are many in number generally, and are situated around the optic nerve-entrance, or they follow the course of the blood-vessels in the nerve-fibre layer. They are in the lower and outer quadrants most frequently. They are seen as black, reddish- or yellow-brown spots, round or oval, sometimes linear striated or "flame-shaped." The retina is clouded or hazy very often, the vessels are pale, the arteries reduced in size, the veins enlarged. In some instances an œdema of the disk or a neuro-retinitis has been observed, and Mackenzie noted white patches and yellow spots in the effused blood, due to "leucocyte infiltration, and to degeneration in the disturbed retinal tissues."

The changes in the blood have been described under Anatomical Alterations, so that it is unnecessary to enumerate them a second time.

Complications, Duration, Prognosis.—The complications of idiopathic anæmia are rare—in fact, pneumonia, erysipelas, and dysentery (Quincke, one case) are the only ones that have been observed. Sequelæ are absent in those that get well, but the progress to full health is slow and fitful, and may be marked by serious relapses. The duration is variable. The average appears to be about five months. In some few instances the disease has terminated as early as six and eight weeks after its inception. The writer's fatal case was of three years' duration, dating from the first evidences of failure in health. Coupland found that 12 out of 110 cases were ill for periods extending beyond two years.

The prognosis is generally grave. A small proportion of cases get well. Pye-Smith analyzed 122 cases ; of this number twenty recovered. Two only of the 27 cases of primary essential anæmia collected by Eichhorst recovered. The elements that influence the prognosis are hard to establish. It had been thought that a diminution of corpuscles to 500,000 or under would render a prognosis unfavorable, yet one of Quincke's cases recovered, although there were but 143,000 red corpuscles per cubic millimetre. Quinquand determined that 26.5 Gm. per 1,000 C.c., about one-fifth of the normal quantity, was as small an amount of hæmoglobin as was compatible with life. Yet here again Quincke's observations are at variance. He found in four cases the reduction to be $\frac{1}{8}$, $\frac{1}{10}$, $\frac{1}{18}$, and $\frac{1}{35}$ of the normal ; the last was a case in which recovery took place. The prognosis is more grave under the following circumstances · First, when the disease occurs in a pregnant woman ; second, when there are numerous syncopal attacks ; third, when fever is marked and hæmorrhages are profuse ; and lastly, when cerebral symptoms, apoplexy, paralysis, etc., ensue. Labor pains in a pregnant woman affected with anæmia are the forerunner of death.

Diagnosis.—Idiopathic anæmia must be distinguished from the grave forms of chlorosis and the symptomatic anæmias ; from Addison's disease and the cytogenetic anæmias. The following diseases in addition to the above have been confounded with it, viz., cancer and ulcer of the stomach, chronic Bright's disease, phthisis, ulcerative endocarditis, organic heart disease, and typhoid fever.

The special characteristics of this form of anæmia have been sufficiently indicated in the preceding pages. Without too much detail, the points of difference between some of the above ailments and idiopathic anæmia will now be pointed out.

Chlorosis.—The age and sex peculiar to this disease ; the menstrual relations ; the gastro-intestinal symptoms —perverted appetite, gastralgia, vomiting, and constipation ; the nervous phenomena ; and the deficiency in hæmoglobin without corresponding decrease in the number of red cells, favor chlorosis. Bramwell [45] strongly insists on the therapeutic test. Arsenic he believes is almost a specific in idiopathic anæmia, while it is of no service in chlorosis.

Symptomatic or Secondary Anæmia.—The occurrence of previous organic or functional disease (*e.g.*, cancer or dyspepsia) ; the presence of emaciation, and the minor degree of blood-changes are indicative of this variety of anæmia.

Addison's Disease.—It may be recognized by the extreme exhaustion that attends it with a moderate degree of anæmia only, by the peculiar pigmentation, by marked mental depression, and by the almost constant emaciation.

Cytogenic Anæmias.—The several varieties of leukæmia or leucocythæmia are distinguished by the large increase in the white cells of the blood, and by the structural changes of the respective organs in the splenic and lymphatic varieties. Pseudo-leukæmia, or Hodgkin's disease, is also recognized by the anatomical alterations of the blood-making organs. The myelogenetic variety of pseudo-leukæmia is the most difficult one to differentiate. Marked pain and tenderness in the bones is possibly the only distinguishing feature, apart from the blood-changes. There have no doubt been instances where it was impossible to determine which affection was present, in life.

No attention has been given to a comparative discussion of the cardiac, pulmonary, gastro-intestinal, or cerebral symptoms in the diseases above noted. They are in the main common to all, and only the most captious could make out diagnostic differences. Thus retinal hæmorrhages and papillo-retinitis have been observed not only in idiopathic, but also in the symptomatic and cytogenic anæmias. It is true that a diagnosis of idiopathic anæmia can only be made by grouping together all the fundamental and essential circumstances and symptoms appertaining to a given case, and then, after close analysis, the presence of the disease or its absence be determined. There is no one symptom that is pathognomonic.

Carcinoma and ulcer of the stomach, especially, as is often the case if hæmatemesis, tumor, and fixed local pain may not be present in the course of the disease, are liable to be taken for idiopathic anæmia. In carcinoma the age, the degree of emaciation, the obstinate constipation, and the smaller blood-changes are indices. Hæmorrhage from the stomach is of more frequent occurrence in organic disease ; it is almost the exception in idiopathic anæmia.

Chronic Bright's Disease with or without Albuminuria.—Symptoms are seen not unlike those of idiopathic anæmia, as pallor, œdema, dyspnœa, retinal changes, and exhaustion. The history of the case, the presence at some period of the cardio-vascular symptoms of chronic Bright's disease, the persistence of albuminuria and of the usual urinary changes, leave one to infer the presence of interstitial nephritis. The blood-changes, the feeble dicrotic pulse, the fatty heart, the irregular fever, and the extreme exhaustion do not belong to Bright's disease. The *frémissement cataire*, with other symptoms, led one observer to diagnosticate endocarditis. As in phthisis, in organic heart disease, and in typhoid fever, the appearance of the blood would certainly decide against either of those affections, independently of the presence of local lesions.

Pathology.—This is obscure. Our knowledge of the physiology of the blood ; of the origin, the development,

the destination, and, in many respects, the functions of the red blood-corpuscles, is involved in so much doubt and is so transitory that it is impossible to discover its pathological secrets. Any speculations on the pathology of idiopathic anæmia must therefore be provisional and based on the fact of its essential lesion being a reduction in the number of the red-cell elements. Such reduction must be due either to a check in their development or to agencies which cause their destruction. Certain it is that it is not due to loss of the corpuscles by hæmorrhage, etc., for such circumstances do not obtain in this anæmia.

1. *Anhæmatosis, or Defective Formation.*—(*a*) This may be due to a diminution of the nutritive supply to the blood. If so we would expect the other elements to be proportionately reduced; but the white cells are relatively increased, and the albumen, though reduced, is not proportionately so. Further, in starvation, and in carcinoma of the gastro-intestinal tract, conditions which illustrate the reduction of the supply of pabulum, we find no such diminution in the red corpuscles. Moreover, no anatomical changes have been found in the organs of assimilation to account for grave nutritive interference.

(*b*) Anhæmatosis may be due to changes, either functional or organic, in those structures which are concerned in the elaboration of red cells. To the white corpuscles, the bone-marrow, the spleen, the lymphatic glands, and, finally, the hæmatoblasts, have been attributed the origin of the red cells. It is generally conceded that the marrow of the bones and the spleen are the chief seats of the formation of red corpuscles, and that the nucleated red corpuscles are their direct antecedents. Careful attention has, therefore, been paid to the bone-marrow by many observers. The spleen is not changed in structure. It, as well as the lymphatics and marrow, may be functionally altered, but our knowledge of the physiological processes is not sufficiently refined to determine such alteration. Structural alterations in the marrow have been found, however, and to them have been attributed the origin of the disease. Cases have been recorded which presented, during life, the symptoms of idiopathic anæmia, and in which the bone-marrow was found to have undergone hyperplasia.[46] Opposed to this, however, is the fact that other observers, in a large number of cases, failed to find such marrow lesion.[47] The former believed the marrow lesion to be the primary one, the blood the secondary.

In many instances, however, there have been cases[48] without anæmia in which the bone-marrow had undergone hyperplasia, the patients having died of other diseases. It has not, therefore, been proven that the marrow changes are antecedent, and, in fact, the weight of evidence appears to favor the view that the red marrow is a secondary result. A close relationship undoubtedly exists, however, between leukæmia and idiopathic anæmia.[49]

2. *Hæmophthisis, or Increased Destruction of Red Corpuscles.*—The color of the face, the muscles, and the fat, the deposition of iron in various structures of the body, the increased excretion of iron by the kidneys, and the reduced amount of the metal in the blood, point to a destruction of the elements in the blood which hold it, viz., the red corpuscles. This destruction is, in all probability, simply an exaggeration of the one which takes place physiologically. It seems far more likely that an actual hæmophthisis takes place than that defective formation is the cause of the red-cell reduction, especially in the absence of proof of cytogenetic changes. The nature of the destructive agency is unknown, although it is not impossible that it may be some ferment in the blood.

The sympathetic system of nerves has been invoked to explain the pathology of this disease. The cases are too few in which thorough examinations were made of the ganglia. Moreover, in many instances they were absolutely normal, while in those cases in which structural changes were found it is impossible to determine the sequence; the nerve-lesion may have been, and probably was, secondary. But little importance should be attached to abnormal changes, for in many other diseases similar changes have been observed.

The fatty heart and the alterations in the blood-vessels, whereby hæmorrhages so readily take place, are fully explained by the experiments of Perl, Ponfick, and others. By repeated bleedings they succeeded in causing fatty heart and degenerative changes in the blood-vessels.

Treatment.—Rest, massage, a liberal, nutritious, and easily digested dietary, the moderate use of stimulants, cheerful surroundings, and probably a change of scene, are the chief non-medicinal means used for the restoration of health. Yet no definite results can be given of the beneficial effects of the above means, either singly or combined, unless it be of the last measure. One of Frerich's cases appeared to be cured by removal to a mountainous territory, while, on the other hand, one of the writer's cases improved at a city hospital, suffered relapse in his mountainous home, and was completely cured on his second visit to the hospital.

The usual remedies used in anæmia have been disappointing in this affection. Iron, phosphorus, cod-liver oil, quinine, and strychnia have failed as blood-restorers or general tonics. Arsenic, however, has been found of inestimable service. Its value was first discovered by Bramwell, who used it first from a knowledge of its good effects in fatty degeneration of the heart.

Padley[50] carefully considers the use of arsenic, and shows the results of treatment by this drug in seventy cases collected from various sources. Of the seventy, forty-eight were treated without arsenic: forty-two proved fatal, two were still under treatment, in three the result was unknown, and one recovered (authorities, Hobson, Coupland, Mackenzie, Bramwell, Barclay). Comparing this with the remarkable results derived from the use of arsenic, the most skeptical person will be convinced of its utility. Twenty-two cases were treated by arsenic: sixteen recovered, two improved, and four were fatal (Coupland, Hobson, Bramwell, Finney, Broadbent, Withers, Moore, Lockie, and Padley). The drug should be given in small doses, gradually increasing until its physiological effects are produced. Transfusion has been employed with temporary relief in some instances; rarely has it been actually curative; four undoubted cases only are recorded by Pye-Smith as being cured. Quincke prefers arterial transfusion, others the venous. The transfusion may be done by the direct or by the indirect method. In addition to blood, milk has been used (Thomas, Pepper). It appears that, according to the observations of Von Bergmann ("Die Schicksale der Transfusion im letzten Decennium," Berlin, 1883), a simple saline solution meets all the requirements, and is not by any means as dangerous as the use of the other liquids.

The symptomatic indications for treatment are generally combated on general principles They are gastro-intestinal symptoms, the dyspnœa, the cardiac palpitation, and hæmorrhages. The writer has seen very much benefit derived from the use of caffein for the cardiac debility, four grains being given at a dose, thrice daily.

It is to be regretted that we are compelled to add that often, in spite of the most careful hygienic and medicinal treatment, our efforts are in vain, and the disease progresses to a fatal termination. *John H. Musser.*

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ANÆSTHETICS. Anæsthetics (from α, privative, and αἴσθησις, sensibility) are agents which cause a temporary abolition of sensation. The condition brought about by their administration is termed anæsthesia. They are local and general; the former being applied to a portion of the body produce their effect only at the seat of application; the latter affect the whole system. General anæsthetics are by far the more important; they are administered by inhalation, and by their influence upon the nervous system abolish sensation, produce complete muscular relaxation, and finally cause entire suspension of sensation and the power of motion, together with consciousness, and all manifestations of life except respiration and circulation. They will be considered in relation to surgery and to obstetrics, and as modified in action by the influence of narcotics.

There are a large number of chemical compounds which are efficient general anæsthetics. The only ones now generally used, and which have stood the test of long experience, are ether, chloroform, various mixtures of these, and nitrous oxide gas. The effect of the latter is very transient, it requires special apparatus for administration, and is therefore almost entirely limited to dental practice. It is safe to affirm that the anæsthetics at present in use will not soon be displaced. So vast has been the experience with them that a generation or more must pass away before the greater safety of any new agent could be established.

To abrogate the pain of surgical operations has been an object of study and effort from the most remote ages. The attainment of the long-sought object is one of the great triumphs of recent times and has effected a revolution in surgery. Operations became practical which before were not undertaken on account of their severity; rapidity of execution ceased to be the great aim of the surgeon; dissection of the most delicate tissues could be made undisturbed by the patient's movements, and the operating-table, before which the stoutest heart sank, was transferred from a bed of agony to one of peaceful slumber. The earliest records of attempts at anæsthesia for surgical purposes date from the period of the Roman Empire. Toward the close of the last century great advances were made in pneumatic chemistry, and modern anæsthesia was foreshadowed by Sir Humphry Davy, in 1800, when he wrote: "As nitrous oxide in its extensive operation seems capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great loss of blood takes place." This property of nitrous oxide, although a matter of common knowledge, and although the gas was frequently inhaled as an amusement, for its stimulating effects, bore no practical fruit until 1844. On December 11th of that year, Horace Wells, a dentist, of Hartford, Ct., being convinced of its anæsthetic properties, submitted himself to the influence of this gas and had a tooth extracted without suffering. Most truthfully did he exclaim, on awakening, that "a new era in tooth-drawing" had been entered upon. He was unsuccessful in his attempts to extend his discovery to severe surgical operations for want of apparatus, since invented, necessary for efficient management of the gas, and disheartened by failure he put an end to his life. To him belongs the honor of the discovery; he was the Columbus who first sailed the unknown sea, but did not recognize from the island he touched the great continent beyond. By this time the stimulating effects of the vapor of ether had been discovered, and its similarity of action to nitrous oxide recognized. About two years after Wells' success, September 30, 1846, ether was administered by Dr. T. G. Morton, of Boston, and a tooth was removed without pain. On October 17th this agent was first administered by him for a surgical operation performed by Dr. Warren, and several other successful trials soon followed. It was claimed by Dr. Chas. J. Jackson, of the same city, that he suggested to Dr. Morton the use of ether, and that he, therefore, was entitled to the honor of the discovery. The truth as to the suggestion will probably never be known; actors in the scene, however, state that Dr. Jackson refused to be present at one of the earlier operations, and disclaimed responsibility for any accident which might occur. To Dr. Morton, therefore, rightly belongs the honor of having first carried anæsthesia for surgical operations into practical operation. The names of Jackson and Morton were, however, associated in an attempt to obtain a patent for the process, and they joined in trying to keep secret the article used, so as to profit by the discovery, thus sullying the grandest discovery ever made for the alleviation of human suffering. The adoption of the new method was commensurate with its importance. Before the year closed major operations had been performed in London, and within a few weeks no serious operation was performed at the large hospitals of that city without ether. On January 19, 1847, Simpson, of Edinburgh, first used ether to assuage the pains of labor. Before the close of that year, although here and there dissenting voices were heard, surgical anæsthesia had become general throughout the civilized world. On November 10th, a new anæsthetic was introduced by Simpson, who experi-

mented on himself with various compounds. At the suggestion of Mr. Waldie, a chemist, of Liverpool, he tried chloroform, and on November 15th he published his success with this agent.

Chloroform rapidly displaced ether as an anæsthetic. Being far more powerful a much smaller quantity is required, it is much pleasanter to the patient, more prompt and more enduring in action, and more manageable. For fifteen or twenty years it was almost the sole anæsthetic used, except in the cities of Boston, in this country, Lyons, in France, and Naples, in Italy, where ether has always been preferred. The change would have been permanent had not further experience shown that chloroform sometimes caused sudden death. The increasing frequency of fatal accidents awakened attention and excited fear. Numerous attempts were made to escape its dangers on the one hand, and the inconveniences of ether on the other, by the use of mixtures of the two. The Chloroform Committee of the Medico-chirurgical Society of London, in 1864, recommended, among others, a mixture of one part alcohol, two parts chloroform, and three parts ether, by measure, known as the A. C. E. mixture, which has probably been used more than any other. At Vienna, a mixture of six parts of ether to one of chloroform has been used so much as to be known as the "Vienna mixture;" it is stated that there have been eight thousand administrations of it without a death. Billroth, of the same city, uses a mixture of three parts of chloroform, one of ether, and one of alcohol.

About three years ago inquiries were addressed to representative medical men throughout this country, and from the replies the relative standing of the different anæsthetics would seem to be as follows: Throughout New England ether is the only anæsthetic used. In the large cities of New York, Brooklyn, and Philadelphia, containing two and a half million of inhabitants, but four or five surgeons use chloroform, a few more the mixtures, the others ether. In the western and northern portions of the country, ether is used by a large majority of surgeons, while the reverse is true of the South. Since that time some deaths from chloroform have occurred in the latter section, in the hands of leading men, and have undoubtedly exercised an influence. In all sections of the country some few use a mixture, if not avowedly, yet practically, by adding chloroform when any difficulty is experienced in bringing a patient under the influence of ether. In the hospitals of Great Britain, where ten or fifteen years ago chloroform only was used, now about one-third use ether and another third mixtures. Judging from journals, we may say that a large proportion of practitioners use chloroform. In France, with the exception of Lyons, chloroform is the sole anæsthetic, and the same is the case in Germany, except at Vienna, where mixtures predominate.

There are prominent characteristics of both anæsthetics which are to be considered in making a decision as to which to use. Chloroform is pleasant, ether unpleasant. The small bulk of the former will always give it the preference in military service without question. The vapor of ether is very inflammable; it has been known to ignite at a distance of fifteen feet. This renders its use dangerous by artificial light or with the actual cautery. Beyond these points the relative danger of the two exercises the supreme influence, and it would be most desirable to be able to state that relative danger exactly. This cannot be done in figures. The number of deaths from chloroform exceed 400, yet the number of administrations cannot be known, and all attempts to fix any ratio of the one to the other are vain. In one hospital there was a death with only 525 administrations, while Hunter McGuire saw in the Confederate Army 28,000 administrations, and Nussbaum has seen 40,000 without any fatal case. These are the extremes.

The deaths from ether number about sixty, but the number of administrations is no more accurately known than those of chloroform. It is certain that the frequency of fatal cases has increased of late years as the use of this agent has extended.

It is claimed that with the mixtures much of the danger attaching to chloroform is avoided. The claim is, doubtless, just. Dilution of the vapor prevents that powerful and sudden impression which has often caused death with chloroform, nor can the danger-line be so readily passed from carelessness, or any influence causing irregular administration. More prompt in action, and more manageable than ether, in proportion to the amount of chloroform they contain, they cannot be considered safer than ether. It is a question between practical advantages and an infinitesimal amount of danger. Deaths have occurred from them, but no statistics exist upon which an approximate estimate of the relative safety of mixtures as compared with ether or chloroform can be based. Testimony favorable to some of them has already been given from Vienna. The A. C. E. mixture has been used by the writer almost solely for twenty years; on two occasions only were there any symptoms to cause anxiety, and these on the part of the respiratory organs.

Statistics lacking as to the relative safety of the two leading anæsthetics, the grounds for a decision must be found in experiment on animals and clinical experience. The former cannot alone suffice, because artificial anæsthesia in animals differs in some respects from the same process in man. It has been abundantly shown, however, that in animals under chloroform the blood-pressure and the action of the heart are liable to great and sudden irregularities, and that frequently the latter stops without warning, events which never occur under ether. So marked is this that the term "capricious" has been applied to the action of chloroform by a recent scientific commission. Clinical experience has shown the same irregularity of action. Sudden death has occurred repeatedly, no explanation being possible, in the hands of skilled administrators, with every precaution taken, with apparatus insuring a definite proportion of the vapor, and without apparatus, at the very beginning of the procedure, and with but the smallest dose, to subjects in perfect health, and to those who had repeatedly taken it before, the accident has happened. The closest scrutiny of these cases, the fullest admission of every extenuating circumstance, will not suffice to set aside the verdict that chloroform acts irregularly, and sometimes with energy and effect out of proportion to the dose.

The action of anæsthetics very much resembles that of alcohol. Introduced by inhalation, their effect is more rapidly produced, and as their excretion is mostly by pulmonary exhalation, their influence passes off sooner. Like alcohol, they are carried by the blood to the central nervous system, and produce their effect by an influence upon the molecular changes or structure of those centres. The symptoms produced by them are alteration of perception by the senses, disturbance of the intellectual functions, generally temporary increase of reflex excitability with convulsive muscular contractions, gradual abolition of sensation and consciousness, changes in the pupils, constant changes in the circulation and respiration, relaxation of the muscles, and depression of temperature.

When chloroform is administered there is first experienced a sensation of pungent warmth in the air-passages, a local effect of the vapor, to which speedily follows a glow throughout the body, a pleasant sense of stimulation, with fulness of the head. To this succeeds disordered intellectual action; the patient is delirious, talks incoherently, and perhaps becomes noisy. Having no longer correct perception of external circumstances, he may struggle and resist the administration, and even become so violent as to need restraint. Hysterical symptoms sometimes show themselves, as immoderate laughing, sobbing, crying, or screaming. Vomiting frequently occurs, and is very certain if the stomach be full. The motor disorder may be so great as to be convulsive in character; tetanic spasm of the muscles of respiration and rigidity of the extremities are frequent, while general convulsions sometimes occur. The pulse, generally feeble and small at the beginning from emotional influence, becomes fuller, firmer, and more frequent as the anæsthetic influence progresses. Respiration is, as a rule, very irregular. The pupils are dilated. The inhalation being

continued, voluntary motion ceases; complete muscular relaxation takes place; a lifted limb falls lifeless; sensation is entirely abolished. The pulse is now firm and steady, the respiration deep and regular, the pupils contracted, the countenance as in deep sleep. Reflex action is now no longer shown, the muscles of the eye do not respond when the conjunctiva is touched. The patient is now in a state of complete anæsthesia, and ready for the operation. If the inhalation be pushed farther, the functions essential to life become compromised, respiration is stertorous, the heart's action depressed, and death occurs by failure of one of these, or of both simultaneously, or by profound coma. The administration being discontinued, the patient soon begins to recover, and gradually returns to the natural state, restoration taking place, as a general rule, with a rapidity proportioned to the energy of respiration. Disturbing influences, as dressing the wound, may hasten a return to consciousness, while with perfect quiet, sleep of considerable duration may supervene.

It is usual to describe the different phases of this process as stages of anæsthesia, and to recognize a stage of excitement, one of tolerance, or surgical anæsthesia, one of deep coma, or paralysis, and a stage of returning consciousness. No definite line, however, separates these stages; one gradually merges into the other. The stage of excitement varies very widely; as a rule, it is well marked in the robust and vigorous, and severe in hard drinkers; frequently with females and weak subjects it is entirely absent, and artificial anæsthesia in these is but a gentle and gradual passage into quiet sleep.

The leading functions deserve closer attention. The increased frequency of the pulse of the early stage may amount to from ten to thirty beats; under the full influence it falls to the natural standard, and may descend considerably below. It remains thus, and regular and firm, unless affected by hæmorrhage or long-continued administration. The sphygmograph shows that after the systole the arteries decrease in size rather by elasticity than by active contraction. There is a vaso-motor paresis; everything indicates lowered innervation of the circulatory system.

Cough is excited by the local stimulating effect of the vapor, and is proof that the air is too highly charged with it. Respiration is increased in frequency in the early stages, and is always irregular up to tolerance. During the stage of excitement it is variously affected, sometimes catching and shallow, sometimes scarcely perceptible, and ceasing for considerable intervals. Under the full influence the breathing is regular, soon becoming stertorous if the administration be pushed.

The pupils are dilated and sluggish in the early stages, the dilatation varying in wide degrees up to the time when consciousness is lost. Contraction then occurs; they may be only half the size they were at the beginning. Unless the anæsthesia be profound they respond by dilatation to sharp impressions upon the skin, or to touching the cornea. There is frequently loss of association of the movements of the eyeballs.

Sudden changes in pulse, respiration, or pupils have generally been precursors of danger.

The temperature falls on the average a little over half a degree centigrade. This does not occur until at least ten minutes after inhalation begins.

The physiological action of ether is, in general, very similar to that of chloroform. They differ rather in degree than in character, the effect of the latter being more rapid, more complete, and more enduring. There are, however, some striking modifications. The vapor of ether is far more pungent and irritating. Marked effects of this are salivation and cough. There is often a distressing sense of suffocation; it is more difficult to induce the patient to inhale ether, and more difficult to bring on the full anæsthetic influence. The stage of excitement is far more marked and more violent, and is especially so if the vapor be too much diluted with air. Vomiting is quite as likely, and hysterical symptoms more likely to occur. Erotic manifestations may present themselves, although rarely, but such delusions are a well-known feature of both anæsthetics. Surgical anæsthesia having been obtained by ether, the patient is held in it with more difficulty, he relapses readily into the stage of excitement, and his struggles may interfere with the surgical procedure. Recovery is much slower, ether being retained longer in the organism, and its taste and smell are sometimes distressing for many hours afterward. There may be dizziness or unpleasant sensations in the head for some time, or the patient may be in a state of semi-intoxication, and all these symptoms last for a time proportioned to the time and extent of the etherization.

The accepted doctrine that there is an essential difference between the effect of chloroform and that of ether on the circulation, rests entirely upon experiment with animals. It is not in accord with clinical experience. Sphygmographic tracings show depression always with the former, not always with the latter. But of ten carefully taken tracings during surgical anæsthesia from ether, in seven there was no difference between them and the curves observed under chloroform.

Respiration is more irregular, if possible, under ether. Cough is more frequent and troublesome, but does not indicate the necessity for caution so strongly as it does with chloroform. Stertor is more common, and does not have the grave significance that it has with chloroform.

Dilatation of the pupils is almost constant during the early stages, but the subsequent contraction does not so often occur nor to so great a degree; even in profound ether anæsthesia there is often no contraction.

A fall of temperature takes place, under the same conditions as with chloroform, to a mean of .68° C. (.54° F.).

No accurate observations have been made of the different functions under the mixed vapors, and their action cannot therefore be contrasted with the individual anæsthetics. In general terms it may be said that it partakes of those of the constituents. They are unpleasant and difficult of administration in proportion to the ether they contain, prompt and steady in action in proportion to the amount of chloroform. The alcohol contained in the A. C. E. mixture certainly modifies the rate of evaporation of the other more volatile constituents.

Every particular relating to irregular action and fatal effect of anæsthetics demands the closest scrutiny. Danger is most surely avoided by full knowledge of the manner of its approach. Some preliminary considerations deserve attention. 1. It is not surprising that death should occur in a state in which all but the most essential vital functions are abolished; the wonder rather is that it does not more frequently occur; and he will be the most cautious in the use of these powerful agents who most fully appreciates the physiological fact that a patient in a state of anæsthesia is on the borders of death. 2. All deaths under anæsthetics are not due to them. Sudden deaths on the operating-table have always occurred, and were well known before anæsthetics were used. Two such occurred in Edinburgh during the first years of the use of chloroform, and when it had been administered several thousand times without accident. 3. Very many of the fatal cases afford no clue to the manner or immediate cause of death; they require careful study and comparison, with constant recognition of the necessity of weighing rather than numbering facts before making deductions from them.

In regard to death from chloroform the following negative propositions may be confidently stated: 1. Previous inhalation gives no guarantee of safety; in a considerable number of the fatal cases there had been previous administrations. 2. There is no relation between the severity of the operation and the danger; forty per cent. of the deaths have occurred when it was given for minor operations—strabismus, tooth-drawing, etc. 3. Death does not occur from an overdose in the ordinary acceptation of the term; the regular action of chloroform is progressive, the narcosis deepens gradually, and to carry the process to the extinction of life would be to disregard the plainest warnings. In but a small proportion of cases has the fatal result occurred in the later stages; generally it has taken place quite early, sometimes

within the first minute or two, and when only a very small quantity had been administered. Nearly fifty per cent. of the deaths have occurred before complete anæsthesia. 4. Death does not always occur in any one particular way. Assumption of the contrary is misleading, and has retarded progress. It has been held that death invariably takes place from failure of the heart's action, and that previous administration of a stimulant insures safety; yet a fatal result has many times occurred when full doses of brandy had been given. It has been held that too concentrated vapor is the sole cause of death; yet it has frequently occurred when an inhaler guaranteed due proportion of vapor and air.

Death from chloroform takes place in the great majority of cases suddenly and unexpectedly. Some failure of the pulse, more than usual embarrassment of respiration may precede it, but generally cessation of the heart's action, or of respiration, singly or both together, occurs without warning. Sometimes stoppage of bleeding from the divided vessels, or sudden pallor of the countenance, alone announces that the patient is dead.

The following modes of death from chloroform may be distinctly recognized: 1. That from too concentrated vapor. In animals sudden variations of vascular pressure are very frequently shown upon every renewal of administration, the sphygmographic tracing dips as much as forty millimetres out of one hundred and ten. Clinical experience has repeatedly shown death immediately after a fresh supply has been poured on the sponge. Death is, in these cases, by overdose, not absolutely as to amount but as to amount within a given time. 2. Death from surgical interference during partial anæsthesia. Reflex action of the pupils follows sharp irritations of the skin until anæsthesia is profound; variations of the pulse occur upon severe impressions made by the surgeon. Indeed, reflex actions are more energetic and more marked during the early stages of chloroform anæsthesia. High authority and clinical experience both teach that such reflex influence may proceed from impressions made by the surgeon, extend to the heart, and cause sudden cessation of its action. In many cases death has followed instantly on a painful impression, and as to chloroform, it is certain that a state of partial anæsthesia is one of especial danger. 3. Death during the period of excitement. Physiology and experience both teach that this stage is one of great danger. The fatal event may be brought about by obstructed respiration from the tongue falling backward, or from tetanic spasm of the chest muscles. A very deep inspiration sometimes succeeds to a considerable cessation of respiration; if the air be then overloaded with vapor the limits of safety may be passed with that one inspiration. If, after a deep inspiration of air containing a large amount of vapor, struggling succeeds, the glottis is closed and intra-thoracic pressure greatly increased by the muscular efforts, thereby causing such rapid passage of the vapor into the blood as to be instantly dangerous. The disordered innervation of this stage may extend to general convulsions; in twenty-eight cases they were the precursors of death. 4. By paralysis of the respiratory nervous centre. Respiration suddenly stops, the heart continuing to beat until its action ceases as a consequence of suspended respiration. It has been maintained that this mode of death is peculiar to ether; clinical records show that it took place thus under chloroform in ten out of forty carefully observed cases. 5. By paralysis of the nervous centre presiding over the circulation. This mode of death is more frequent than any other, if not than all others combined.

Careful study of recorded cases shows that death from ether does not differ materially from that caused by chloroform, the chief point being that it does not occur so frequently by failure of the circulatory organs. The following propositions may be safely stated: 1. As with chloroform, sudden death during operation has been often unjustly attributed to ether. 2. No statistics exist upon which can be based a statement of the ratio of deaths from ether to inhalations, or as to the relative safety of the two agents. 3. Death never takes place from inhalation of air too fully charged with vapor of ether, as is the case with chloroform. 4. Reason, experiment, and clinical experience concur in indicating that ether is the safer. 5. It remains an open question whether surgical interference during partial anæsthesia from ether is dangerous, as is the case with chloroform. 6. Death may take place under ether suddenly and by cardiac paralysis, the same as under chloroform. Clinical experience does not support the assumption that ether death is always by the lungs, and chloroform death always by the heart. This is true of animals under ordinary circumstances, but when the trachea is opened and pure ether vapor is carried directly to the lungs, death in them takes place by the heart, and that within a very short period of time. Death has thus been caused in dogs in sixteen seconds. Cases are on record in which sudden cessation of the heart's action took place under ether, and in which the death differed in no particular from a typical death by chloroform.

Death sometimes occurs after the close of the administration of either anæsthetic. Some time, several minutes, after the operation has been completed and the inhalation has ceased, respiration or circulation has become embarrassed and a fatal result has rapidly followed. Many cases have been reported in which dangerous symptoms came on at this period, and the patient was rescued, but with difficulty. Thus far this form of death remains inexplicable; the danger has appeared too long after the administration ceased to be ascribed to the vapor of the residual air. It seems probable that this unusual course of events has followed ether more frequently than chloroform. In aged subjects a rapidly fatal suffocative catarrh has sometimes followed the administration of ether.

There are no contra-indications to anæsthetics so far as the surgical operation is concerned. All doubts felt in the past as to increase of mortality from their use, or as to any deleterious effect upon the after-progress of the case, have been resolved, and they are now universally given whenever severe pain is to be inflicted. Age is no bar at either end of the scale of life. They have been administered up to the nineties, and the writer has given chloroform for convulsions with success to a child twenty-four hours old, and to one, for hare-lip operation, of forty hours. The general opinion, that chloroform is entirely safe in early life, is not supported by facts; there have been deaths of children; nor are there any statistics upon which a statement can be based that it is safer for these subjects. Probabilities are favorable to the view that chloroform is safer than ether for the aged. Scarcely any condition of disease forbids the use of anæsthetics. If albuminuria be present, only severe operations would justify their use; ether is especially dangerous in this condition, as first recognized by Dr. Emmett. Neither disease of the lungs nor disease of the heart, except it be advanced or severe, forbids them. As to valvular disease of the heart, observation has shown that the action of this organ is steadier and better under an operation with than without chloroform; and even in case of fatty degeneration the patient is probably safer with an anæsthetic, although ether should be preferred; chloroform has been frequently given in this condition with safety. Anæsthetics justify the performance of operations after injuries under conditions in which they would not be advisable without them. Authorities differ as to their administration during shock, yet there is no doubt that the surgeon need not wait for complete reaction, nor that the safety and interests of the patient are promoted by his early interference. Of course, much must be left to individual judgment, and extreme depression of the vital powers forbids operation. Ether, or the mixed vapors, should be preferred in these cases. Chronic alcoholism is an extremely bad condition for anæsthetics. They should be administered to hard drinkers with more than usual caution, and only under pressure of necessity.

The patient should prepare himself for anæsthetics by abstaining from food for some hours previously, whenever possible, or the preceding meal should be a light one; vomiting is thereby escaped or lessened, and the danger of solid masses of food finding their way into the larynx is avoided. The clothing should be loose and free about

the neck and chest. An examination of the urine for albumen should be made if time permit, especially if ether is to be given. The condition of the heart may be disregarded if the operation is imperative. The recumbent position is important, and should be as nearly approached as possible in operations on the mouth and face. The patient's mouth should be examined, and plates of false teeth, tobacco, etc., removed.

Upon proceeding to, and while conducting, the administration of an anæsthetic, several important points should be borne in mind. The patient's mental condition deserves the first consideration. To the dread of the operation is added that of the anæsthetic, the danger of which is not unknown, and to his mind most probably exaggerated. A marked emotional state of this character has been a feature of, and probably has played a part in producing, a considerable number of fatal cases. A quiet, steady manner on the part of the administrator will inspire confidence and allay anxiety, while assurances and encouragement will be demanded. The temperature of the room should be noted. Air will carry more than double the amount of chloroform vapor on a hot day than it does at the ordinary temperature of an apartment in winter. In other words, if by an inhaler four per cent. of vapor is being given at 50° F., by a rise of temperature to 70° F. the per cent. of vapor will be 9.5. The vapor of all anæsthetics is considerably heavier than air, that of chloroform more than four times heavier. Therefore, raising the apparatus a few inches directly upward from the patient's mouth and nose does not suspend the administration. There is constantly in the lungs and bronchial tubes a volume of air from five to seven times as large as the tide of each respiration; time should now and then be given for the vapor of this residual air to pass into the blood. This is especially necessary, as complete anæsthesia is approached, and only applies to chloroform. Hearing is the sense last abolished, talking should not, therefore, be permitted, and especially no remarks should be made about the operation.

An inhaler is not necessary for giving chloroform. The apparatus used should insure a due supply of air, with equable mixture of air and vapor, should permit the process to be steadily progressive, and should render impossible, especially during struggling, sudden transitions from inspirations containing almost no vapor to air loaded with all it can carry. To pour chloroform on a towel and thus give it, is to violate all these principles. Nature has provided a perfect instrument in the cup-shaped sponge. One should be chosen with a cavity about the size of the fist. A proper temperature is secured by dipping the sponge in warm water; and to provide an equal mixture of air and chloroform vapor, during the administration of the anæsthetic, it is well to squeeze the sponge gently as the liquid is poured on it. The amount of chloroform necessary to produce surgical anæsthesia in an adult of average size is the vapor of eighteen minims, that amount being absorbed and carried in the blood. But the dose must be a clinical one, *i.e.*, judged by its effects. About half a fluid-drachm should be first poured on the sponge, and this held a short distance from the mouth or nose. The first point to attain is tolerance of the air-passages and mental quietude of the patient. Coughing indicates that the vapor is too strong. The sponge may be gradually placed more closely over the nose and mouth, as air can pass freely through its meshes. In two or three minutes about the same quantity of liquid may be poured into it again, and this repeated from time to time. Close watch should be kept of the pulse, respiration, and countenance. Very high authority has taught that the first and last may be disregarded and attention paid alone to the respiration. Nevertheless, in sixteen out of twenty-one fatal cases, a sudden change in the pulse first announced danger. For the struggles of the stage of excitement such restraint must be used as will permit the administration of the anæsthetic to go on. Vomiting, if the stomach be empty, may be disregarded; if, however, it be full, the patient should be turned on his side and the act promoted, great care being taken to clear the mouth of pieces of food and to prevent them from passing into the air-passages. Screaming and other hysterical symptoms are soon quieted by pushing the administration. For temporary suspension of breathing the patient may be shaken pressure be made on the chest as for artificial respiration, or the face or chest slapped with a wet towel; after a little delay the function will resume its ordinary course. Great care should be exercised at this time that a deep inspiration of air fully charged with vapor does not take place. Regular respiration and absence of all muscular power will show that complete anæsthesia is at hand, failure of the muscles of the eyelids to respond on touching the conjunctivæ will announce that it is attained. This condition of the patient is to be maintained by renewed application of the sponge from time to time, the administrator keeping close watch of pulse, respiration, and countenance, and not allowing the operation, or anything relating to it, to distract his attention. The time required for the whole process is from five to eight minutes. Rapid administration is dangerous. By prolonged inhalation the system becomes charged with the agent, recovery is slow, and is accompanied by more unpleasant symptoms.

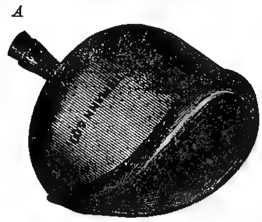

FIG. 162.—Lente's Inhaler (reduced in size).

For the administration of ether an inhaler is advisable. Economy is effected by it, but far more important points are the prevention of diffusion of the vapor throughout the apartment, and the insurance of prompt and efficient anæsthesia. An inhaler should be simple, inexpensive, and easily cleaned; it should afford an enclosed space around the mouth and nose for the vapor and air, and is better if provision is made for excluding the latter entirely at will. Lente's inhaler (Fig. 162) is a simple metal mask, on a sponge in which the ether is poured. The tube at *A* is fitted with a perforated cork; as the administration proceeds the cork can be introduced, and if necessary still farther to exclude air the perforation can be closed with the finger. The ingenious inhaler of Dr. Allis, of Philadelphia (Fig. 163), consists of an oblong metal frame, through slots in the side of which a roller bandage is woven. A leather cover surrounds the whole, and ether is dropped on the folds of the bandage as the patient inhales (Fig. 164). This inhaler affords a very large surface for evaporation, and insures a due supply of air. For the administration of mixed vapors it is an excellent instrument. The most rapid and efficient anæsthesia is only effected by inhalers of which a closed bag is a feature. Dr. Hutchinson's (Fig. 165) is such an instrument. It consists of a rubber face-piece,

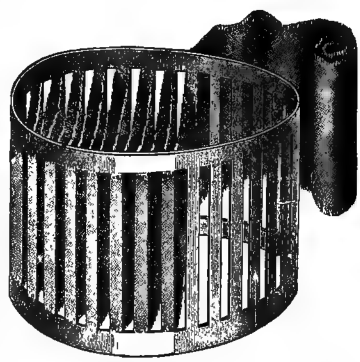

FIG. 163.—Allis's Inhaler (reduced in size).

FIG. 164.—The Same, in Use.

A, a metal cylinder, *B*, attached to a closely woven muslin bag, *C*. The bag is wrung out of water, the cylinder filled with coarse sponge moistened, and the ether is poured in through the opening provided with a stopper. Instruments of the same kind are Dr. Squibb's, of Brooklyn, and that of Drs. Rohé and Leonard, of Baltimore. The exclusion of air by these instruments is not absolute. Even were it so, there is no danger for a brief period ; but there is a certain portion of air always in the bag, and some gains access around the face-piece. Rapid anæsthesia by ether is not dangerous, as with chloroform ; some excellent authorities advocate its production in even less than three minutes.

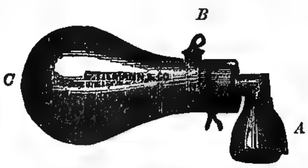

FIG. 165.—Hutchinson's Inhaler (reduced in size).

In the absence of an inhaler ether may be given by means of a cone of stiff paper with a sponge in the apex, or from a folded towel. Great care should be exercised that these, when wet, do not fall down on the mouth and nose, thus preventing inhalation both of vapor and air.

Administration of ether should be conducted on the same principles as those which govern the administration of chloroform. Tolerance of the air-passages and assurance of the patient are the first step. Two ounces of ether is sufficient for an ordinary operation with Dr. Hutchinson's inhaler, and with this or with any of the closed instruments, the air-openings should be left free during a few inspirations and then gradually closed. With other apparatus, but a small quantity should be poured on at first. As soon as possible the quantity of ether should be increased and the air gradually excluded. The dose is not by measure, but by effects. Timidity is as great a mistake, although not so dangerous, as is rashness with chloroform. Suffusion or duskiness of the face are not bad symptoms, nor does stertor indicate cessation of the administration.

There is no great difference in the administration of the mixed vapors ; they are prompt in action and require caution in proportion to the amount of chloroform. For the A. C. E. mixture a large cup-shaped sponge is the best apparatus. If squeezed out occasionally before a fresh supply is poured on, the objection, constantly made, as to the constituents evaporating at different rates, is entirely obviated. It is doubtful if the closed sac-inhalers should be used for these mixtures, certainly not with the air-openings shut.

The accidents of anæsthesia are to be met with the same coolness and knowledge of resources as other exigencies of surgical life. They call for the prompt application of remedies for stimulation or restoration of the functions of the circulatory, respiratory, and nervous systems. The first step is to see that the air-passages are free and maintained so. Howard's plan is the best ; elevation of the jaw by pressure behind the condyles, or pulling the beard, with forced extension of the head. In no case should the chin be depressed or the head bent forward. The tongue may also be pulled forcibly forward. Forced expiration, by pressure on the chest, should be effected simultaneously. Then should follow complete inversion of the body. The value of this method has a rational basis, anæmia of the brain being present in anæsthesia, but it rests also on experiment, and on clinical experience so abundant as to render impossible any "*post-hoc*" explanation. The patient not responding promptly, artificial respiration should be resorted to. Sylvester's plan is the best. (See Artificial Respiration.) It should be thoroughly and patiently carried on ; the lungs are the great channel of excretion, and recovery has often followed long perseverance in such efforts. If paralysis of the heart has occurred, the patient is beyond recovery ; but cessation of its action may be only apparent, being so lowered as to be imperceptible. In this case artificial respiration is the most powerful means of increasing and maintaining cardiac action, and is therefore the leading and most reliable means of resuscitation. Other measures of relief may be demanded. If the breathing be evidently obstructed, especially after vomiting, laryngotomy should be performed ; death has several times occurred from impaction of food in the glottis. Electricity is a powerful excitor of the respiratory acts, and has rendered good service in several instances. Eminent authority could be cited adverse to the use of this agent. Nitrite of amyl has been strongly urged ; its action in lowering blood-pressure does not give it theoretical support, while if respiration be in abeyance its vapor cannot be carried into the lungs. Under these circumstances it has been used hypodermically. In case the circulation remains feeble for some time an enema containing brandy may be given, or the latter may be administered hypodermatically.

The action of anæsthetics may be hastened and their effect prolonged by narcotics previously administered. "Mixed anæsthesia" is the best term for this combined effect of the two classes of agents, the result being rather an addition of the influence of one to the other, than a modification. The practice was first resorted to by Nussbaum, who gave a hypodermic injection of morphia during chloroform narcosis in order to prolong it. Bernard investigated the joint influence of the two, placed the method on a scientific basis, and showed the greater advantages to be derived from the narcotic preceding the anæsthetic. The stimulant effect of morphia, in its earlier stages, shown by increased blood-pressure, is well known, and its antagonism to the depressing influence of chloroform is therefore valuable. This may be promoted by the simultaneous use of atropia, a powerful stimulant of the heart and circulation. Further, reflex action, so active and sometimes so deleterious under chloroform, is lessened by the obtunding influence of the narcotics. The method consists in giving hypodermically from one to one and a half centigramme of morphia (one-sixth to one-fourth grain), with a small amount of atropia, a short time before administering the anæsthetic. The writer constantly uses from six to ten minims of a solution containing sixteen grains of morphia and half a grain of atropia to the ounce of water. From fifteen to twenty minutes should elapse between the injection and the administration of the anæsthetic. There can be no reasonable doubt that the danger from chloroform is much lessened by this method, especially for operations of long duration or great severity. Further advantage may be justly claimed, being based on large clinical experience: 1. Emotional excitement, always distressing, doubtless sometimes the source of danger, is very much lessened, if not abolished. 2. Anæsthesia is produced much more rapidly, maintained more easily and steadily, and with a much smaller quantity of the agent. 3. The period of excitement is moderated and shortened ; with hard drinkers this is a point of great importance, and the claim has been made that with this class danger is very much diminished by this method. 4. Vomiting is believed to be less frequent and less severe. 5. Absolute quiet of the patient is secured, a point of great value in delicate operations. In the dog the lingual artery can be tied at its point of emergence, deep in the throat, under mixed anæsthesia, an operation which cannot be performed under either morphia or chloroform alone (Bernard). 6. The stage of recovery is quieter, with greater freedom from pain of the operation, the patient often passing hours in slumber. There can be no doubt of the high value of this method as a convenience to the administrator of the anæsthetic and to the surgeon, and as a source of safety and increased or more certain immunity from suffering to the patient.

By far the greater part of published experience with mixed anæsthesia relates to the combination of narcotics with chloroform, and one high authority has declared against their use before giving ether. The writer has always used them preceding the A. C. E. mixture, and in a considerable experience has never seen any bad effects from this combination.

It is not surprising that agents which so rapidly and profoundly affect consciousness should be used for crim-

inal purposes. In fact, instances occurred early in their history, and have since been frequently repeated, so that their relations in this respect have become a subject of importance in legal medicine. On the other hand, their use has been frequently alleged in cases of assault upon women, or where explanation of or excuse for a robbery was necessary. So great is the ignorance in the public mind of their action, and so exaggerated an idea of their powers prevails, that such allegations receive ready credence, and the grossest injustice has been more than once perpetrated. Whatever may be the particular character of such cases, the circumstances are very apt to be perplexing and the testimony conflicting. The practitioner, when called upon as an expert, may safely rely upon the known physiological action of the agent used, and in this alone he will find a reliable guide; only by keeping this clearly in mind will he be able to instruct the jury and promote the ends of justice.

Chloroform is to be almost solely considered in this connection. The vapor of ether is too irritating, its action too slow and uncertain, unless a special apparatus be used, to render it available for criminal purposes.

In the first place it may be stated that all claims, such as have been made, that a person has been instantaneously overpowered, as by thrusting in the face a handkerchief or towel saturated with the liquid, may be summarily dismissed. The time required for the production of a state of anæsthesia, even approaching to a loss of power of resistance, is too great, even with the co-operation of the party, to allow such a claim to be entertained for a moment.

It was for a considerable time an open question whether chloroform could be administered during sleep without awakening the party, and its importance needs no emphasis. In investigating the subject it has been found that something depends upon individual peculiarity as to soundness of natural sleep, much on the age of the subject, and far more upon the mode of administration. Adults are usually awakened upon the attempt being made, unless the inhalation be conducted slowly and with great caution, while children can be generally anæsthetized without sleep being broken. It may be stated very positively, then: 1, that the production of anæsthesia by chloroform during sleep is possible with adults, but requires great caution and very considerable skill in execution; 2, that if two persons be in the same bed or room, it is highly improbable that both could be brought under the influence without awakening one of them; 3, that with children it is more readily effected, and, with care, it would probably be successful in a majority of cases.

The statement is not infrequently seen in the press that a robbery was effected by impregnating the air of an apartment with chloroform vapor to such a degree as to render the inmates unconscious. It may be confidently asserted that such an occurrence is impossible under ordinary circumstances. For a chamber only ten feet by twelve, and eight feet high, one and a half grain of the agent to the cubic inch being necessary to produce complete anæsthesia, it would require no less than thirty-eight fluid ounces, or nearly two and a half pints of the liquid. This would be the quantity theoretically; practically, from the great relative weight of the vapor as compared with air, causing it to sink toward the floor, it would require much more. Farther, all doors and windows would have to be closed, nor could the perpetrator remain in the room without being brought to the same condition as his victims.

In regard to the administration of chloroform to women for purposes of criminal assault, the same principles apply. The difficulties of administering it during sleep have already been stated. If it be given while the person is awake, and without her consent, some fabric, wet with it, must be forcibly held over the mouth and nose until unconsciousness supervenes, sometimes a difficult task on the operating-table. In effecting this there would certainly be a violent struggle and ample opportunity for outcry. But there have been some notable cases in which an anæsthetic, ether or chloroform, was administered with the consent of the party, as for tooth-drawing, and advantage taken of her helpless condition to commit a rape, or a charge of such an assault has been preferred afterward. All such cases are very weak without corroborative testimony of other witnesses or circumstances; the unsupported evidence of the woman is in the highest degree unreliable. Erotic sensations are a feature of artificial anæsthesia. Manifestations of them have been witnessed, although rarely, but dreams of a sexual character are doubtless far more frequent and are extremely vivid. How frequently they are experienced it is impossible to know; women are doubtless more liable to them than men, and especially when the administration of the anæsthetic takes place at or about the time of periodical pelvic congestion. Such dreams are believed to be more frequently produced by ether than by chloroform, from its more stimulating effect. A knowledge of these facts should imperatively restrain the practitioner from ever administering an anæsthetic to a woman unless in the presence of other persons. Cases have occurred in which the woman was so positive that liberties had been taken with her person during anæsthesia that the testimony of relatives who were present all the time scarcely sufficed to convince her that she was laboring under a delusion. When such charges are preferred, and in cases, such as have occurred, where the plaintiff was awakened by the administration of the anæsthetic and swears that an outrage was perpetrated, her testimony must be weighed by the standard of the known action of these agents. If, for instance, she swears to circumstantial details of the assault while she was unable to resist or cry out, her testimony does not agree with the fact that mental confusion is one of the early effects of an anæsthetic; if she swears, as has been done, to penetration, to experiencing pain, while at the same time she was unable to alarm those sleeping in close proximity, her evidence does not harmonize with the fact that sensation is abolished long before muscular power; active resistance to an operation is often seen, the patient not being entirely under the influence, when upon awakening there is not the slightest knowledge of what has occurred. The practitioner may possibly be cross-questioned as to the occasional irregular action of the anæsthetic. This may be supported by the adduction of cases, given by good authority, in which it is stated that patients have observed an operation performed upon them, have been conscious of the procedure, and yet have suffered no pain. The question may then be put whether, this irregularity being established, there may not be others, and, therefore, whether it may not be possible for a person to be conscious of pain or of other sensations under an anæsthetic, and yet be incapable of resistance or of outcry. The reply may be made to such queries, that the irregular cases adduced belong almost entirely, if not exclusively, to the early history of anæsthesia, to a period when the passing wonder of the process dazzled men's observation of facts. A careful examination of the literature of the subject has failed to discover any recent cases of this kind, nor has very considerable experience furnished any. In regard to irregularity of action, it may be stated that anæsthetics are as constant in their mode of action, as little liable to variation as any medicinal agents, and that such wide departures from their ordinary effect as consciousness of pain with inability to resist or make outcry, is in the highest degree improbable, and only to be accepted as a fact upon abundant positive testimony of competent observers.

The following summary of this branch of the subject is taken from Wharton & Stillé's "Medical Jurisprudence," vol. iii., 1884, and the propositions may be positively assumed as correct:

"1. That the consciousness or perception of external objects and impressions is impaired in the early and lost in the final stage of etherization.

"2. That during the time the mind remains susceptible to external impressions at all, these reach it in a feeble or perverted manner.

"3. That the emotions, and especially those of an erotic character, are excited by the inhalation of ether.

"4. That voluntary muscular movement is not para-

lyzed until the state of perfect narcotism is produced, at which time, however, all outward consciousness is extinct.

"5. That the memory of what has passed during the state of etherization is either of events wholly unreal, or of real occurrences perverted from their actual nature.

"6. That there is reason to believe that the impressions left by the dreams occasioned by ether may remain permanently fixed in the memory with all the vividness of real events."

In cases where disease is feigned the administration of an anæsthetic affords the most speedy and certain means of discovering the deception. Whether the practitioner has a right to resort to such a measure, without the consent of the party, is exceedingly doubtful. Before proceeding upon such dangerous ground, rendering himself liable to a suit for damages, he had better fortify himself with a legal opinion, the question being one of right, and therefore legal rather than medical.

The production of anæsthesia for the major operations of obstetrics differs not at all from that for surgical operations. The same considerations influence the choice of the agent, and the same general rules govern administration. One point, possibly, requires emphasis. If anæsthesia be resorted to for version, and in but few cases should it be performed without it, the patient must be carried deeply under the influence of the reagent. If the accoucheur proceeds to turn before the anæsthesia is profound he will certainly fail, especially if the case is a delayed one or if he be short of skilled assistance. It requires deep anæsthesia to abolish uterine contraction and action of the abdominal muscles under the stimulus of introduction of the hand. But anæsthetics are resorted to in obstetrical practice for the mitigation or abolition of the pains of natural labor, and it is to this use of them that the term *obstetrical anæsthesia* applies, and which is to be now considered.

The first administration of ether during childbirth was made by Simpson, of Edinburgh, on January 19, 1847. In about a month afterward he published a paper giving the result of his experience in natural labor, and setting forth the important fact that the pain of parturition could be moderated or annulled without interfering with uterine contraction or expulsive effort. Soon afterward Dubois read a paper before the Academy of Medicine sustaining Simpson's observations and conclusions. Cases were soon reported in this country by Dr. Walter Channing, of Boston, and in 1848 he published a "Treatise on Etherization in Childbirth," containing reports of about six hundred cases, which exerted a powerful influence in establishing the practice. The introduction of chloroform by Simpson, and its administration by him in natural labor, followed toward the end of 1847. This agent rapidly supplanted ether, its superiority being more manifest in obstetrics than in surgery. The smallness of its dose, the lack of necessity of special apparatus, its pleasant odor, the non-inflammability of its vapor, and, above all, its rapidity of action and great manageability, peculiarly fit it for the lying-in chamber. But a very moderate administration of it is necessary before pain is relieved by its effect on the sensitive nerves. In this respect it is, to use the happy expression of Bernard, a "physiological scalpel," which, in the living body, isolates particular tissues with more minuteness and precision than can be done by the anatomist in the cadaver.

The administration of anæsthetics for the pains of labor did not achieve the rapid triumph of surgical anæsthesia. The procedure was novel, the practice revolutionary, and there was fair standing-ground for opposition to interference with a physiological process for the abrogation of pain which was inherent to it in accordance with the course of nature. The conservatism of human nature showed itself, and there was strong opposition to the innovation. In this country the powerful influence of Meigs, of Philadelphia, was arrayed against it; in Great Britain that of Barnes, Montgomery, and Ramsbotham; in Germany it was opposed by Siebold and Scanzoni. Medical societies and journals were for a time occupied with the question, and the press issued a large amount of controversial literature upon the subject. The Scriptures were dragged into the contest, and the advocates of mitigation of suffering during labor found it necessary to defend themselves against the charge of an impious interference with the decrees of Providence. Some of the arguments in opposition were simply ridiculous. Thus, great stress was laid on the occasional and very exceptional erotic manifestations under anæsthetics, and it was urged that the pains of labor would be transformed into exhibitions of sexual passion! It was gravely argued that the maternal instinct would be diminished or abolished, and that there would be no love for offspring in the heart of a mother who had not suffered in bringing them forth! Finally, any anæsthesia short of surgical was denied, and mitigation of pain with preservation of a certain amount of consciousness claimed to be impossible, and the practice, therefore, a mere pretence, its benefits having no existence save in the imagination of the patient! Nevertheless, the benefits were so apparent, and injurious consequences, either to mother or child, so entirely lacking, that the practice steadily gained ground. In Great Britain nothing so powerfully contributed to the disarming of prejudice and the complete success of the method as the example of Queen Victoria. Never has it been given to a woman to exert so great an influence upon scientific progress as in this case. In 1853, at the birth of the late Prince Leopold, she inhaled chloroform at the hands of Snow, and again in 1857 at the birth of the Princess Beatrice. The fact was announced by the medical press in tones of astonishment; nevertheless, the effect both upon the public and the profession was immense, and from that time open hostility to the practice ceased. In France opposition to obstetrical anæsthesia was more effective, and the contest is not yet over. Many influences combined to retard its adoption. Surgical anæsthesia was slower in gaining a footing there, outside of Paris, than in any other country of the world. Twenty years after its discovery it was not resorted to for operations in many of the provincial cities. Official influence is more powerful there than elsewhere, and the heads of the obstetrical branch of the profession declared against it. Without the influence of the Anglo-American colony of Paris it would probably have made no headway, and notwithstanding the able advocacy of some eminent men, especially at the Medical Congress at Geneva in 1877, the administration of anæsthetics for mitigation of the pains of natural labor is today under official ban. Everywhere, however, except in France, obstetrical anæsthesia has triumphed over all opposition. Mitigation of the pains of natural labor by anæsthetics is considered entirely justifiable, if not a duty which the accoucheur cannot deny to a patient who demands it. There is not a text-book in our language which teaches any other doctrine.

On account of the qualities already stated, chloroform is almost exclusively used in obstetrical practice, and especially for mitigation of suffering in natural labor. The question of danger from its use deserves the first consideration. The most rigid scrutiny, inspired by hostility, has failed to show that when judiciously used it exerts any injurious influence upon the mother or the child. So far as danger to life is concerned, under the above conditions it approaches as near to zero as in the use of any of the more active agents of the Pharmacopœia. Chloroform has been used in natural labor many hundred thousands of times, yet but a single case of death is on record where it was administered by a competent medical man, and in this there is lack of post-mortem confirmation. Three other cases have been given at second hand and without particulars. It is manifestly unjust to attribute death to the anæsthetic where such powerful lethal influence as convulsions or placenta prævia was present, and such cases are excluded. Now and then a note of warning has been raised, never superfluous in regard to the use of powerful agents, inspired by some cases in which dangerous symptoms have been manifested, yet it may be confidently stated that if we abstained from the use of chloroform in natural labor on account of the danger or threatening symptoms which immense experience has furnished, consistency would

require that we abolish almost every one of our most effective remedies, if not abstain from the ordinary occupations of daily life. Indeed, immunity from accident is such a striking and singular fact, especially in view of the occasional irregular action of this agent, and of the small dose in which it has sometimes proved fatal, as already stated, that great ingenuity has been exercised to frame a satisfactory explanation. There are some very evident sources of security to the parturient woman under chloroform: 1. A certain amount is due to sex; the deaths of males to those of females are more than two to one. 2. The small dose required to mitigate pain and the gradual mode of administration. 3. The absence of depressing emotional influence; the remedy is welcomed, not dreaded. But all these do not afford a satisfactory solution, and there is probably some special source of safety either in the process of labor or the patient's condition. The facts that obstetrical experience furnishes no deaths from chloroform, even when given for operations, that the highest rate of mortality from this agent has been in young, strong, and muscular subjects, while at the same time military practice has given the largest number of administrations with the smallest proportion of deaths, give good ground for the hypothesis that the existence of pain at the time of administration is a strong guarantee of security, and may afford an explanation of the immunity of women in labor from accident.

Clinical observation is the best guide to the study of the action of chloroform upon the different elements of labor. The composite nervous supply of the uterus from both cerebro-spinal and sympathetic systems the facts that many questions in regard to the relative influence of these yet remain unsettled, and that there is not unanimity of opinion as to the location of the uterine motor centre, render a physiological study impossible. The uterine contractions, or "pains," are the most important element of the process, and upon few questions has there been greater diversity of opinion, by equally competent observers, than as to the influence of chloroform upon these. Some have claimed increase of force and frequency, others diminution of energy with lengthened intervals, and others again that they were entirely unaffected. Doubtless all are, in a measure, right. Exceptionally, where the parts are hyperæsthetic, the patient nervous and over-sensitive, or where the pains are spasmodic in character, they will be rendered more regular, more frequent, and more efficient by the anæsthetic. In general, however, the effect of chloroform depends on the period of labor, somewhat on individual peculiarity, and very largely on the dose. In these facts may be found an explanation of differences of opinion far more marked in the past than at present. The earlier in the labor chloroform is administered the more likely is it to delay or modify the pains. As to the dose, the action of the agent is the same here as with the general nervous system; regularly progressive pain is first alleviated, then abolished, motor power being affected later. With the small dose necessary for obstetrical anæsthesia the uterine contractions are, in the great majority of cases, unaffected. When pushed farther, however, they tend to become feebler and with longer intervals. If narcotism be carried to an extreme, they are, for a time at least, abolished. Upon the latter fact depends one of the greatest benefits of anæsthesia, viz., an increased facility of performing version, especially in cases in which there has been delay. That individual differences exist in regard to this point there can be no doubt. Quite frequently the pains diminish in force and frequency of return as the influence of chloroform is first felt. In the majority of such cases after temporary suspension of inhalation the same effect will not be observed. Sometimes, however, although rarely, it persists. The writer has seen cases in which the remedy could not be continued on this account. Playfair advises substitution of the A. C. E. mixture for chloroform under these circumstances. The general rule is, that in proper doses, and carefully—not too rapidly—given, chloroform has no effect upon the uterine contractions, and does not, therefore, delay labor.

Nearly the same may be said of the abdominal muscles as of the contraction of the uterus. Their action is unaffected by small doses, and, indeed, anæsthesia must be considerably advanced to interfere with it. They are supplementary in function to the respiratory muscles, and derive their nervous supply from the same nervous tract, a part of the nervous centres which succumbs last to the influence of anæsthetics. Anæsthesia of the ordinary degree for obstetrics may be maintained for hours without interfering with this powerful auxiliary to labor, but if pushed to the deeper stages there is a tendency to its failure. As the patient loses consciousness she cannot, of course, exert that volition upon which the efficient assistance of these muscles in part depends. In cases, therefore, where unusual demand is made upon these efforts, and upon this part of the apparatus of labor, where, for instance, the fœtal head requires considerable moulding to enable it to pass through the pelvis, it may be advisable to suspend the inhalation while this is effected. This may be done with less hesitation, since the moulding process, although sometimes tedious, is the least painful part of labor.

The action of chloroform upon the cervix is extremely favorable to the progress of labor by promoting that dilatation which is a necessary part of the process. This effect is produced by lessening suffering and by its relaxing influence upon the tissues. There is no point upon which the testimony is so strong and so harmonious as this. Nor can there be a more striking instance of the beneficial effect of a remedy than is frequently seen in cases where the head is about to engage in the os, the pains active and expulsive, and the patient sensitive. Under such circumstances the suffering is extreme. To avoid the acute pain the patient holds back voluntary effort, and represses as much as possible the supplementary action of the abdominal muscles, thus delaying the labor. As soon as the severe pain is blunted by the anæsthetic, voluntary effort is made and the head is forced through the os from contact with which it was before instinctively kept back as much as possible. The favorable influence of chloroform on the os is shown in abnormal conditions, rigidity, spasmodic contraction, and extreme sensibility. So marked is its beneficial effect in these conditions, that tartar emetic, venesection, and belladonna have been banished as relaxants, and it remained the one especial remedy for these conditions until rivalled by chloral. When chloroform is resorted to solely for relaxation of the os, anæsthesia should be carried somewhat beyond the ordinary obstetrical degree.

Relaxation of the perineum is promoted by chloroform. The muscular constituents of this last obstacle to the birth of the child are rendered supple and more yielding before the advancing head. The testimony in regard to this is almost unanimous. As the vulva becomes distended and stretched to the utmost the pain often becomes excruciating, and here again anæsthesia shows its happy influence. The favorable influence of chloroform is here not alone anæsthetic. There is no doubt that its use is one of the most efficient means of preventing rupture of the perineum. Besides its relaxing effect a further beneficial influence can be called forth by carrying the anæsthesia on to the surgical degree during the closing part of the process. That instinctive and voluntary effort which tends to force the head too rapidly through the vulva is moderated or abolished, and by delaying and diminishing the uterine contractions for a brief period, especially by moderating the auxiliary force of the abdominal muscles, that time is gained which is essential for the necessary yielding of the tissues. Frequently, by means of two fingers in the rectum, the head can be made to gently clear the vulvar orifice in the interval of pains and during complete unconsciousness of the patient.

Regular and firm contraction of the uterus after labor is most important, and in it alone lies the safety of the patient; retained placenta and flooding are the consequences of lack of it. That retention of the placenta by active, irregular—hour-glass—contraction is more frequent after the use of chloroform has never been maintained. In regard to retention from lack of contraction—uterine inertia—it is difficult to judge from the wide range of time for

the completion of the third stage of labor under any circumstances. No statistics exist upon which this charge against chloroform could be based, if it were made. The question of such an amount of uterine inertia being caused as would render *post-partum* hæmorrhage more frequent or more severe is a far more serious one, and demands careful consideration. Here again the dose influences the result. If the amount given be small, and if it be carefully and judiciously administered, it does not promote the occurrence of uterine inertia. Physiological action of the remedy, however, shows that if pushed to the extent of surgical anæsthesia, especially for any considerable time, its tendency is to diminish uterine contraction. In large doses, therefore, and when long continued, the possibility of hæmorrhage must be recognized and guarded against. When circumstances have demanded a free or long-continued use of chloroform, the administration of ergot should not be neglected as the labor draws to a close, or immediately upon its termination, and the accoucheur should exercise the most scrupulous watchfulness until firm uterine contraction has existed for such a time as to give assurance of safety.

The administration of chloroform during natural labor differs materially from that for surgical purposes. While the one is a regular progressive process carried steadily to a definite point, the other is a continuous state of partial anæsthesia; in the one the patient is so deeply under the influence that return to consciousness of suffering requires considerable time; in the other, the influence is slight, and readily passes off, or, on the other hand, may be carried too far for the most beneficial results. The entire procedure is based on the regular progressive action of the agent and of the different stages of its influence which can be distinguished. There is, 1, partial loss of sense of pain; 2, disordered consciousness, partial loss of voluntary motion, almost entire loss of sensation; 3, entire loss of consciousness; 4, complete loss of motor power; 5, cessation of uterine action, surgical anæsthesia. To these would follow cessation of the heart's action and of respiration. The object of the accoucheur is to hold his patient in the second stage, avoiding on the one hand an advance to the third, and, on the other, a relapse into the first. To accomplish this for a considerable time satisfactorily is by no means an easy task. The stages are not divided from each other by well-marked lines, but shade off gradually into each other. Success in the management of obstetrical anæsthesia requires, therefore, the most scrupulous care, incessant watchfulness, and considerable skill, only to be acquired by practice, and the process entails upon the accoucheur no small amount of extra fatigue, not to say anxiety. As to apparatus for administration, but one addition is required to the cup-shaped sponge. That is trifling in character, but important in insuring success; it is nothing more than a cork provided with a dropping-tube. It is important that the liquid be poured out in very small quantities, and by this means only a few drops can be shaken out at a time. Notwithstanding all that has been written as to its necessity, no assistant is required. The accoucheur alone can conduct the entire process and manage the labor. In the early stages there is ample opportunity for examination; later, with one hand he observes the advance of the head, and with the other applies and replenishes the sponge. If the patient be in the English position, he can sit or recline on the bed behind the patient, her hips being brought close to the edge, and thus each hand can command its field of duty. The patient being brought to the stage of relief of pain by a few deep inhalations of the vapor, she is best kept there by applying the sponge for a few inspirations just as the pain is coming on. Her assistance can be invoked for keeping the anæsthesia at the desired point. Even for pains of considerable severity she need not be carried beyond a stage of talking sleep, out of which she returns to full consciousness as the pain comes on, and then exercises the force of the abdominal muscles in bearing down. A very considerable experience has not furnished an instance of an improper word being spoken or gesture made in this condition. As the head is about to pass the vulva the anæsthesia may be deepened, and sometimes should be. Just at this period, if the vulvar opening be small and rupture of the perineum appear imminent, it may be necessary to confide the sponge for a brief period to the nurse; the physician, however, must himself control the amount of liquid put on it, and will keep constant watch of the patient's face and respiration. The head being delivered, administration of the anæsthetic ceases.

The accoucheur must be the judge as to the cases in which to resort to anæsthetics. Not every case of labor requires them; in many, "effort" is far more marked than "pain," and as a general rule this is in proportion to muscular exercise and a lack of those refining and enervating influences which cause at once an over-development of the nervous system and intolerance of pain. The type of a labor best adapted for the use of chloroform, and in which it most markedly shows its benefits, is one in which, with ample pelvic space, expulsive force preponderates over dilatation. Here the head is forced along a canal not yet relaxed for its passage, thereby causing most acute suffering, while under these circumstances there is no fear of delaying the process by carrying anæsthesia somewhat farther than ordinary. The time of labor when the administration of an anæsthetic should first begin also varies. During a large part of the early stage it is not demanded, and when it is, the administration should be delayed until the endurance of the patient begins to be taxed, in view of the uncertainty as to the length of time during which it may be required. The periods at which it is most needed and most beneficial are during the passage of the head through the two narrowest points of the soft parts, the cervix and the vulva; at these, relaxation is favored, and relief of the most severe suffering rendered.

Local anæsthesia is effected by refrigeration of the part to be operated on. Various other measures for obviating the pain of operations, such as compression of the nerves, tight ligating of an extremity, were formerly in vogue, but very imperfectly succeeded in their aims, and by the discovery of general anæsthesia have been consigned to forgetfulness. The production of insensibility to pain as an effect of cold was first noticed by John Hunter while experimenting on animals. It was observed in human beings by Baron Larrey in operating on the wounded after the battle of Eylau, during intensely cold weather. Dr. James Arnott, of London, first formally advocated and used cold as a means of escaping the danger of administering chloroform for minor operations. His method consisted in the application of ice and salt to the part. This has been almost entirely superseded by refrigeration by means of ether spray, an apparatus for effecting this having been invented by Dr. B. W. Richardson, of London, and this method of local anæsthesia originated with

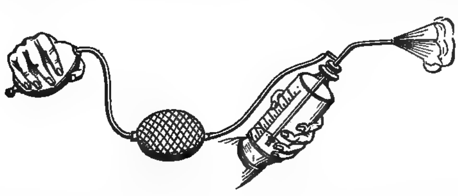

FIG. 166.—Richardson's Spray Apparatus, for the Production of Local Anæsthesia.

him. His instrument (Fig. 166) is too well known to need description. By means of it ether is projected from the terminal tube in fine spray, causing rapid and great reduction of temperature; the mercury in the thermometer can be brought within a few minutes to several degrees below zero, F.

To use Dr. Arnott's method, two parts of pounded ice are mixed with one part of common salt and the whole enclosed in a gauze or muslin bag of coarse texture. This is then applied to the part to be operated on for a period of from four to ten minutes, until it assumes a white and tallowy appearance. If the spray apparatus be used the ether should be chemically pure, *Ether Fortior*

of the Dispensatory, and the spray is to be played on the part until the same appearance of the tissues is produced, when the operation may commence. The effect is only upon the skin, or the parts immediately subjacent.

In producing anæsthesia these plans, Dr. Richardson's particularly, are tolerably efficient, and the method is well adapted for brief minor operations, such as opening abscesses, removal of small cysts, evulsion of nails, etc. The impression of so severe a degree of cold, however, and the reaction from it, are not devoid of pain. The statement is made that reaction after these methods is not to be feared, and that inflammation or sloughing does not occur. The general rule has many exceptions, and it would not do to rely upon it, especially, for instance, in a case of plastic operation.

As this article is being drawn to a close, a discovery has been made of inestimable value to the profession and to humanity, and one which changes materially the relative position of general and local anæsthetics. A true anæsthetic has been found, an agent which abolishes sensation without affecting consciousness, and one which exerts no injurious effect upon the parts to which it is applied. This substance is the hydrochlorate of cocaine, a salt of the active principle of the Erythroxylon Coca.

The benumbing effect of coca leaves on the tongue when chewed has been noted ever since they were known to the profession. This power was first utilized by the application of a concentrated infusion of the leaves in painful affections of the larynx and pharynx (*La Tribune Médicale*, 1882). A solution of the salts of cocaine, and especially of the hydrochlorate, came into pretty general use for obtunding the sensibility of the throat, by laryngologists of Germany. Dr. Koller, of Vienna, then studied experimentally its effects on the eye in animals, observed its anæsthetic action on this organ, and extended its application to man. He formally introduced the article to the profession as an anæsthetic for operations on the eye at the Ophthalmological Congress held at Heidelberg in September, 1884, and its powers were verified to the satisfaction of members of the Congress. The intelligence was transmitted to this country by Dr. H. D. Noyes, of New York, and the new agent was welcomed with a warmth and enthusiasm without parallel. The medical journals of every week contained additional evidence of its value in operations upon the eye, and reports of its use as an anæsthetic for operations upon other parts of the body.

The eye presents conditions peculiarly favorable for the action of a local anæsthetic, a moist surface which absorbs rapidly. When a few drops of a solution of the hydrochlorate of cocaine are dropped into the conjunctival sac there is, at first, a slight sensation of warmth, with some increase of the lachrymal secretion, then follows a feeling of dryness with complete abolition of sensation, both tactile and painful, which lasts for from seven to ten minutes. In about a quarter of an hour dilatation of the pupil occurs, but this mydriatic effect is not as marked nor as persistent as that of atropia.

The transient effect of this agent makes frequent repetition of the applications necessary. Instillations of a four per cent. solution should be made three or four times, at intervals of about five minutes, in order to anæsthetize the eye. The limitation of its effect to the branches of the terminal nerves with which it comes in contact renders it necessary, in operations involving the deeper structures, to follow up the incisions with the solution, or to inject it into the tissues with a syringe. This plan has been followed in enucleation of the ocular globe with fair success, but at the expense of considerable prolongation of the operation. For incisions of the conjunctiva and sclerotic, however, simple instillation produces complete anæsthesia, and in this way the operations of iridectomy, those for strabismus, pterygium, and cataract have been frequently performed without pain. So reliable and perfect is the action of this agent that the day of general anæsthesia for ophthalmic operations may be said to have passed away. As a means for facilitating the removal of foreign bodies from the cornea, and diminishing or abolishing blepharospasm, the value of cocaine cannot be overestimated.

The attempts to induce local anæsthesia of the skin by applications of the solution of cocaine, have not been very successful; aided by hypodermic injections, a few operations, such as removal of small growths, have been effected without pain. But for operations involving the mucous membranes, the anæsthetic effect is more reliable. As an injection into the urethra to obtund the sensibility for the passage of a catheter, or for internal urethrotomy, it has been successfully used. For painful affections and hyperæsthetic conditions of the anus and vulva it has yielded good results, and its anæsthetic effect has been induced for operations upon the vagina and uterus. Even trachelorrhaphy has been performed by its aid, with more or less diminution of suffering. Further experience will doubtless increase the reliability and extend the range of application of the agent for operations of this character.

One of the most marked benefits derived from the local anæsthetic effect of the solution of cocaine is in laryngeal phthisis. In many cases patients have been enabled to swallow with comfort, after having the throat brushed with the solution, when before they could not take food without most distressing cough and severe suffering. For this purpose, as well as for many of the operations indicated, a stronger solution should be used than for the eye, a solution of from twelve to twenty per cent.

It is impossible to fix accurately, at so early a period of its history, the limits of the application of this anæsthetic, the discovery of which is one of the greatest triumphs of modern surgery. *J. C. Reeve.*

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ANAPHRODISIACS. These are remedies employed to diminish undue sexual appetite. They may be divided into three classes: moral, hygienic, and medicinal. The first embraces the influence of religion upon believers, the exercise of a strong will-power, and the avoidance of all exciting causes, such as immoral pictures, novels, or plays, and lewd conversation. The hygienic remedies are chiefly local cleanliness, a spare diet, the avoidance of stimulants and of animal food and spices, light clothing about the hips, sleeping upon a hard bed, cold baths, and active mental or physical employment. The principal medicinal anaphrodisiacs are the bromides, camphor, conium, digitalis, the nauseants, salicin, and cold applied to the spine or to the genital organs. The most frequently employed, and the most reliable, of these agents are the bromides of ammonium, potassium, or sodium. Camphor is sometimes very efficient, but it is not as reliable as the bromides. Conium and digitalis are seldom used for this purpose, though the latter is said to possess very certain anaphrodisiac properties. Willow bark formerly enjoyed a great popular reputation as a subduer of the sexual passion, and salicin is probably equally efficient. As a temporary measure, the production of slight nausea finds no equal in destroying the sexual appetite, and next to this comes the application of ice to the spine or the perineum. * * *

ANASARCA. The full term originally used was hydrops anasarca (hydrops, from Greek, ὕδρωψ; anasarca, from Greek, ἀνά, into, and σάρξ, flesh; Fr., *Anasarque;* Ger., *Anasarka, Hautwassersucht, Hautoedem*).

By the term anasarca is meant the collection of a fluid in the lymph-spaces of the subcutaneous connective-tissue and intermuscular septa, throughout the body. The use of the word anasarca is only warrantable when the process is a generalized one. When it is localized, the term œdema is used, giving with it the name of the part affected; thus one speaks of œdema of the feet, eyelids, or scrotum, but not of anasarca of the feet, eyelids, or scrotum.

This fluid in the lymph-spaces is a thin, clear one, of a specific gravity varying from 1.010 to 1.018; much poorer in albumen than the blood serum; showing microscopically a few leucocytes, and occasionally, though rarely, coagulating when exposed to the air. The fluid is transuded blood-serum, and corresponds in its characteristics to lymph. The process consists, then, in an overcrowding and overdistention of the lymphatic vessels and spaces with lymph, and to this process the general term of œdema is applied, to distinguish it from dropsy, which means an abnormal collection of a like fluid in the larger, preformed spaces in the body—pleural or peritoneal cavities, for example. Hence anasarca is an œdema of the integumentary layers.

The conditions leading to anasarca are those under which œdema in general arises, namely, from engorgement, from hydræmia, from inflammation.

In œdema from engorgement, one has to do with an obstruction to the flow of blood in the veins, leading to an increased transudation of the blood-serum into the surrounding lymph-spaces. The absorption by the lymphatic vessels not being as rapid as the transudation, the fluid collects, distending the spaces. Anasarca from the above cause is seen in connection with valvular disease of the heart, more especially that form affecting primarily the mitral orifice.

Hydræmic œdema is due to a watery condition of the blood, together with changes in the walls of the blood-vessels. Anasarca under these conditions is most commonly found in the later stages of chronic diffuse nephritis; though it should be stated in this connection that Cohnheim, who has done much toward establishing the doctrines of œdema at present held, thinks that engorgement from incompetency of the heart plays an important rôle in the production of anasarca in this disease.

Œdema from inflammation represents an exudation from the vessels of the part affected; just as in any inflammation an exudation of some sort occurs. The type of an anasarca, due to inflammation, is to be seen in the general œdema of the skin in scarlet fever, where, from the inflammatory changes in the skin, the vessel walls become sufficiently altered to allow the blood-serum to transude.

The gross appearances resulting from anasarca are sufficiently characteristic. The parts are enlarged, often greatly so, as in the penis and scrotum; the folds in the skin are obliterated, the skin often being markedly stretched; the skin and deeper-lying tissues are slightly translucent; of a doughy consistency; readily pitting on pressure, the depression remaining for a considerable time. The color is either very pale, as in the anasarca associated with chronic nephritis, or else dusky or cyanosed, as in the anasarca dependent upon obstructive heart disease. When a vertical section is made into the part, the subcutaneous connective-tissue is found to occupy a much thicker area than usual, and to present a translucent, jelly-like appearance. On firm pressure considerable clear fluid can be pressed out, with a proportionate collapse of the affected tissue. Microscopically examined, the part shows an exceedingly delicate reticulum or meshwork of connective-tissue enclosing spaces, these spaces being filled with the fluid and lined, for the most part, with flat endothelial cells. In other words, one has to do with a connective tissue, the lymph-spaces in which have become greatly distended with lymph.

Although in anasarca the œdema is a generalized one in the integument, yet certain portions are invariably more affected than others. Thus the feet, legs, scrotum, penis, eyelids, and face are almost always more œdematous than is the skin of the trunk and arms. Further, under treatment, the fluid usually disappears last in the parts first named.

The nutrition of the skin in anasarca is much below the normal. It is for this reason that abrasions, as a rule, show no tendency to heal; on the contrary, they are apt to lead to the formation of ulcers, which, in turn, become larger and larger.

The *treatment* of anasarca varies according to the cause. When dependent upon mitral disease, rest and digitalis are of great value by diminishing the venous engorgement. It is not at all uncommon to see an extensive anasarca wholly disappear under this treatment.

In chronic nephritis much less can be accomplished. Sweating by the subcutaneous injection of nitrate of pilocarpin, .01 Gm. (one-sixth grain), or by the hot-air bath, often diminishes the anasarca to a slight extent, but there are many cases where neither of these measures has the slightest apparent effect. Diuretics are usually not of much value, owing to the condition of the kidneys, but the hydragogue cathartics, like sulphate of magnesia 15 to 30 Gm. (℥ ss. to ℥ j.), or elaterium .01 Gm. (one-sixth grain) will frequently, by producing large watery evacuations, diminish considerably the anasarca. Puncture of the skin, especially of the scrotum and legs, with an ordinary sewing-needle, in many places, will often afford relief to the patient by relieving the tension of the overstretched skin. In such cases, however, one is liable to have leakage from the punctures for several days, often making the patient uncomfortable from the wetting of the bed, and requiring frequent change of the bed-linen.

W. W. Gannett.

ANCHYLOSIS. (Synon.: Stiff Joints; Fr., *Ankylose*, *Roideur* or *Soudure des Articulations;* Ger., *Verwachsung der Gelenke.*) The condition of a joint in which motion is permanently abolished or impeded. According as one or the other condition prevails the anchylosis is said to be true or false, complete or incomplete, bony or fibrous. The term is applied to fixation of an articulation in any position, and not necessarily in an angular one, as its etymology would seem to imply. In true anchylosis (synostosis) there is bony union between the opposing articular surfaces, and in consequence of this, motion is absolutely nil. In the greater number of cases the union is intra-articular and involves destruction of the joint. In rare instances, however, anchylosis may occur from a new growth of bone bridging over the joint and wholly external to it. This takes place with greater frequency in the vertebral articulations, though it may be produced in any of the other joints by a process of ossification, involving the ligaments or other peri-articular structures. There is another form of true anchylosis by fusion of the opposing joint cartilages (synchondrosis), which Hueter regards as of more frequent occurrence than osseous union. It may be produced either through the intervention of the synovial processes or by direct union of the cartilaginous surfaces. This form may also pass over into true bony anchylosis. False, fibrous, or incomplete, anchylosis (syndesmosis) may be either intra-articular or extra-articular. Usually it is due to adhesions forming within the joint as a result of inflammation or disuse, but may sometimes be occasioned by fibrinous deposits in the tissues around the articulation. False anchylosis may also be due to ligamentous shortening or muscular contractures, or to cicatricial retraction of the integument and underlying tissues after burns, in leprosy, etc. In the case of anchylosis from extra-articular causes, adhesions within the joint are usually produced secondarily. In false anchylosis there is almost always more or less motion, and even when there is apparently none, there is an absence of that feeling of solidity on manipulation which is presented by a joint in the condition of true osseous anchylosis. There are other conditions simulating anchylosis, in which, however, the restriction to motion is not permanent and dependent upon structural alterations, but is due to the muscular spasm of chronic joint-disease or hysteria. This may be called apparent anchylosis. Apparent may be transformed into false anchylosis by the formation of adhesions within the immobilized joint.

Anchylosis, of the spine especially, may exist as one of the phenomena of old age, occurring merely as a result of senile changes and not from disease. The joints may also become more or less stiffened from disuse or from being maintained habitually in one position. From this cause arises the anchylosis of the fingers sometimes seen in drivers, and the kyphosis of gardeners. The spine and the smaller articulations are those in which "anchylosis from occupation" most frequently occurs; but this seeming predisposition is merely accidental, for the large joints may become rapidly stiffened, if, as in the case of fracture of a long bone near the articulation, they are immobilized for any great length of time. The danger of anchylosis of a joint from disuse is, however, greatly exaggerated in the minds of many surgeons. Anchylosis, when it occurs from this cause, is usually fibrous; but when the factor of pressure is added to immobilization, as in lateral curvature of the spine, true osseous union may take place. Gout, rheumatism, especially so-called gonorrhœal rheumatism, and arthritis deformans are prolific causes of stiffening of the joints. Penetrating wounds of the joints often result in a loss of mobility. Contusions, burns, or inflammation of the peri-articular structures may lead to the exudation and organization of lymph, and consequent impairment of motion in the part. Arthritis, when the inflammation is confined to the synovial membrane, is usually followed by no permanent stiffening of the joint. An exception to this occurs in acute suppurative synovitis, where anchylosis is the rule. But when inflammation has invaded the osseous structures, more or less stiffening of the joint is almost certain to occur. When the osteitis is of short duration and mild in its character, the resulting anchylosis may be simply fibrous; but when the inflammatory process has been long continued and of considerble intensity, and accompanied by suppuration, there ensues a direct bony fusion of the opposing articular surfaces after erosion of the interlying cartilages. In certain diseased states, notably in arthritis deformans, so-called chronic rheumatic arthritis or rheumatic gout, anchylosis occurs by a bridging over or ensheathing of the joint by new bony formations, or by ossification of the ligaments, tendons, or other tissues about the articulation. Motion may also be impeded by new osseous or other growths within the joint, by reason of which the normal relations of the opposing articular surfaces are altered. In such cases there are no adhesions, either fibrous or bony (at least in the earlier stages), but full normal motion is rendered impossible by the mechanical resistance of the intra-articular tumor.

The *diagnosis* of these different forms of anchylosis is not always an easy matter. It is, of course, certain that osseous union is not present if any motion, however slight, be detected; yet here we have to guard against the error of mistaking movement in a neighboring joint for that of the one under examination, as, for example, motion may appear to exist at the hip or shoulder when in reality the movement is that of the pelvis or the scapula. And on the other hand, in false, or even in apparent, anchylosis the joint may seem to be perfectly rigid. There is, however, a feeling of absolute immovableness in a truly anchylosed joint; it is as if the two extremities of the femur were grasped and the attempt were made to bend the bone. But in fibrous or apparent anchylosis, however impossible it may be to detect even the slightest degree of motion, there is, nevertheless, a sensation of insecurity about the joint; it feels as though perseverance were all that was necessary to finally force it to yield. Sometimes the application of poultices and the use of massage for a few days will result in the restoration of a very slight degree of mobility, enough at least to prove that bony union does not exist. Malgaigne's test is one that may sometimes prove useful, but depending, as it does, upon the patient's ability to locate accurately the pain caused by manipulation, it is liable at times to be misleading. The test is made, in the knee-joint for example, by grasping the thigh with one hand and the leg with the other, and then endeavoring to flex or extend the leg, persisting in these efforts until pain is elicited. If the pain be referred to the joint itself, the anchylosis is false, but if it be rather at the parts of the limb where the tissues are squeezed by the surgeon's hand, it is probable that actual welding together of the bones has taken place. Another sign of undoubted value is muscular action. If, on attempts to move the rigid articulation, the muscles are seen to contract and the tendons of insertion to become prominent, the anchylosis is fibrous. In true bony anchylosis no muscular action follows attempts at passive motion. If there is much induration in the deeper tissues about the articulation, it is quite possible that we may have to do with an extracapsular fibrous anchylosis. The induction of profound anæsthesia will remove all doubt in the case of apparent anchylosis, for the reflex muscular spasm of arthritis and the contractions of hysteria invariably relax if the patient be brought deeply under the influence of ether or chloroform.

Treatment.—Much may be done in the way of the prevention of anchylosis by bringing about an alteration in the causative conditions. The stiffening joints of old age may be rendered more supple by passive movements and active exercise combined with friction and inunction of vaseline or oleic acid. In anchylosis from position or occupation it is sufficient, of course, to recognize the cause in order to remove it. In the case of fracture of a long bone the neighboring articulation should never, as a rule, be immobilized for a longer period than three weeks. At the end of this time, ordinarily, passive movements may be undertaken with entire safety. In chronic articular osteitis, the endeavor should be made to maintain the

joint in that position in which anchylosis will occasion the least inconvenience. When permanent malposition of the joint is threatened, in consequence of burns or contusions, the limb should be kept upon splints in such a position as to oppose as far as possible the cicatricial contractions, and as soon as the cicatrix is sufficiently firm, passive motions should be commenced and continued for a considerable length of time.

In anchylosis due to exudation of lymph about the articulation, massage and passive motion will often suffice to promote absorption and restore the utility of the limb. In flexion due simply to permanent muscular contractions, stretching, either manual or by means of a suitable apparatus, will generally produce the desired result. Such a procedure, however, is usually very tedious, and consumes much valuable time, and it is often on this account better to proceed at once to tenotomy.

At one time, not many years ago, there existed a wide difference of opinion concerning the relative merits of gradual and sudden rupture of the adhesions in fibrous anchylosis. It was contended by the opponents of the latter method that a sudden forcible rupture of the adventitious bands was a measure attended with many and great dangers. It was asserted that pyæmia and tearing of the nerves and vessels and soft parts about the joint were the not infrequent results of *brisement forcé*, and the method was condemned as unjustifiable by most of the conservative surgeons of the day. It has been shown, however, that most of the evil results attending the early essays of this operation were attributable to the failure of its advocates to discriminate between true and false anchylosis, and *brisement forcé* is now regarded as one of the safest operations of its magnitude in surgery, provided it be done with due care and with a certain knowledge of the joint conditions. The sudden and forcible rupture of the fibrous adhesions has the manifest advantages over the gradual method in that it obviates the necessity of frequent administration of an anæsthetic; it accomplishes at once what the other plan endeavors to do only after prolonged treatment, and it is far less likely to set up inflammation in the affected joint. The chief objection to *brisement forcé* lies in the danger of epiphyseal separation, an accident that has occurred several times when the operation was undertaken in children. The danger of diastasis in forcible rupture is, however, much less than is that of setting up inflammatory reaction in the joint by the frequently repeated traumatism attendant upon attempts at gradual reduction of the deformity.

Before attempting the forcible reduction of an anchylosed joint it is in most cases necessary to divide the tendons of the flexor muscles. This operation should be performed subcutaneously, and, if possible, some days before the operation upon the joint is undertaken, in order to avoid the danger of tearing the small incisions in the skin into great rents. This accident, with its serious consequences, has happened more than once when *brisement forcé* was attempted immediately after tenotomy. The patient having been brought thoroughly under the anæsthetic, the trunk or central segment of the limb, according to the joint operated upon, is fastened securely to the table. The patient should lie in such a way as not to interfere with full flexion of the affected joint; usually on his back, but if the shoulder is the joint affected, the patient should lie on his face so that the scapula may be steadied. Everything being now in readiness, the operator seizes the free extremity of the limb, and after a few to and fro motions, in order, as it were, to become acquainted with his ground, he suddenly and with considerable force endeavors to flex the joint. In many cases the adhesions will yield at once with a sharp crack, or series of cracks, sounding very much as if the bone had been fractured. After flexion has been obtained the limb should be extended to its fullest limit, and moved in all the other directions of which the joint is capable. Then, when the adhesions are well broken up, the limb is to be immobilized for a few days in the position of the original deformity, after which time, if no inflammatory reaction have taken place, passive motion may be cautiously begun. This may at first be so painful as to require the administration of ether, but it is seldom necessary to induce anæsthesia more than once or twice, and then usually only in the case of children or of the more delicate and timid adults. Emollient applications should be made to the articulation at the same time that passive movements are given. Should diastasis unfortunately be produced, the operation must of necessity be abandoned until the epiphysis has reunited to the shaft of the bone. The accident seldom leads to any more serious consequences than the interruption to treatment, but it has sometimes excited such grave troubles as to require amputation of the limb. It may happen that no amount of manual force which the operator can bring to bear will be sufficient to cause the adhesions to give way, and the question will then arise whether it is justifiable to employ mechanical force. As a general rule it is not. It is always dangerous to use mechanical force alone, but it may in certain cases be advantageously employed as a supplement to the living and feeling strength of the surgeon. The accompanying figure, from Brodhurst, represents the manner in which this power may be ap-

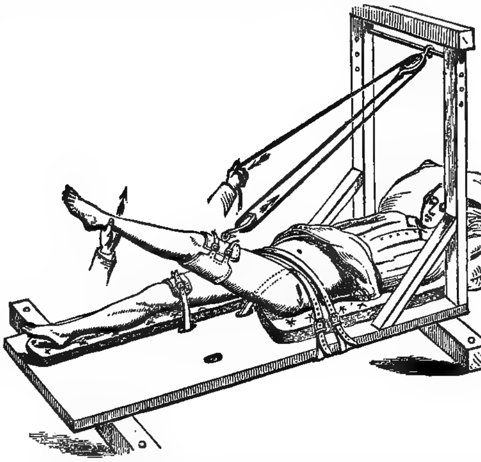

FIG. 167.—Apparatus for Breaking up the Adhesions in False Anchylosis of the Hip. (Brodhurst.) The hand represented in the figure is that of an assistant steadying the limb; the operator's hand is placed under the lower end of the thigh.

plied in the case of anchylosis of the hip. The pelvis is firmly strapped down to the table, and then the limb is strained up as far as possible by means of the cord and pulleys. The operator then grasps the femur below, and exerts a sharp upward force in the direction of flexion of the thigh. It sometimes happens that full motion cannot be obtained by any force which it is safe to apply. Such failures are usually due to shortening of some portion of the capsular ligament. The limb may be nearly straightened, but returns to its former position as soon as the opposing force is relaxed. In some cases of anchylosis of the knee, with or without subluxation of the tibia, it may be found impossible to straighten the limb owing to the tendency to posterior dislocation of the lower segment. This is due, according to Barwell, to shortening of the anterior crucial ligament.

In the treatment of true anchylosis the question is one usually of rectification of a vicious position only. It is true, some operators claim that they can restore a very useful degree of motion by the creation of a false joint, and such a result has in certain cases been obtained. The chances, however, of this fortunate issue are slight, and even in those cases in which for a time there has been some motion, the divided ends of the bone have generally reunited. An operation, therefore, in the case of osseous anchylosis ought, as a rule, to be undertaken only when the joint is fixed in a bad position. Osteoclasis, or fracture of the bone by direct force without cutting, has been tried repeatedly, but has not given such satisfactory results as to lead to its general adoption. In

osteotomy the bone may be divided by the chisel or the saw, and through an open wound or subcutaneously. An operation proposed by Dr. Brainard, of Chicago, consists in drilling through the newly formed bone in several directions, so as to weaken it, and then fracturing the remaining portion. The drilling is performed subcutaneously. Barton, of Philadelphia, removed a wedge-shaped piece of bone from the femur just above the anchylosed knee, thus obtaining a straight limb. Sayre, of New York, divides the femur just below the great trochanter by a semilunar incision, rounding off the end of the lower segment so as to make it fit into the depression in the upper portion. By this operation he has obtained motion in anchylosis of the hip. Resection has been advised and practised in anchylosis of the knee, but the cases in which it is necessary must be extremely rare.

For a more extended account of anchylosis, and of the operations for its cure or correction, the reader may consult:

Barton, J. Rhea: On the Treatment of Anchylosis, etc. Phila., 1827.
Bonnet: Traité de Thérapeutique des Maladies Articulaires. Paris, 1860.
Hueter: Klinik der Gelenkkrankheiten. Leipzig, 1876.
Brodhurst: Orthopædic Surgery. London, 1876.
Bauer: Lectures on Orthopædic Surgery. New York, 1868.
Barwell: Treatise on Diseases of Joints. London, 1881.
Sayre: Lectures on Orthopædic Surgery. New York, 1883.
De Saint-Germain: Chirurgie Orthopédique. Paris, 1883.
Lagrange: Traitement de l'Ankylose du Genou. Paris, 1884.

Thomas L. Stedman.

ANDABRE, in the Department of Aveyron (43° N. Lat.), a village possessing chalybeate springs. The analysis of Limousin-Lamotte shows the following composition of the water:

Total solids, 32.43 parts per 1,000, consisting of:

Sodium chloride	0.79
Magnesium chloride	0.12
Calcium chloride	0.15
Sodium sulphate	7.00
Sodium hydrocarbonate	18.29
Magnesium hydrocarbonate	2.34
Calcium hydrocarbonate	2.85
Ferrous carbonate	0.65

Traces of silicic hydrate and a certain amount of partially free carbon dioxide.

H. F.

ANEURISM. An aneurism of an artery is a circumscribed tumor composed of a sac, the cavity of which communicates with the lumen of the artery, and contains liquid or coagulated blood. The sac may be formed in whole or in part of the distended wall of the artery, or of the condensed adjoining tissues.

Definitions and Classification.—The terminology of the affection has been much confused by a lack of agreement in the use of terms and in the meaning attached to them. Most of these terms are intended to indicate differences in the composition of the wall of the sac, some of which cannot even be recognized with certainty on direct examination, and are not marked by any corresponding clinical differences.

Internal and External.—Internal aneurisms are those situated within the thoracic or abdominal cavity; *external* aneurisms are those formed at the expense of arteries lying outside of these cavities. (*Medical* is sometimes used as a synonym of internal; *surgical* of external.)

Spontaneous and Traumatic.—Spontaneous aneurisms are those that have arisen in consequence of disease or gradual change in the wall of an artery. A *traumatic* aneurism is one which has formed in consequence of sudden mechanical division or injury of the wall of an artery, as by a knife or splinter of bone.

The following anatomical classification, adopted by Holmes, is the one in common use. The distinction made between "true" and "false" aneurisms is anatomically justified, but the terms are likely to mislead, for "true" aneurisms, in the narrow sense of the term, aneurisms whose walls are everywhere composed of all the coats of the artery, are rare and always small; the common form of aneurism belongs to the class termed "false," those in which only one of the coats of the artery takes part in the formation of the wall of the sac.

I. Common or encysted aneurism, subdivided into

(*a*) Aneurismal dilatation, or fusiform aneurism. The artery is dilated for some distance, and the wall of the dilated portion preserves its three coats.

(*b*) True aneurism. The sac is formed throughout by all the coats of the artery dilated at only one point.

(*c*) False aneurism. The sac is formed by only one or two of the coats of the artery, the middle one having disappeared or being unrecognizable in consequence of change.

(*d*) Consecutive or diffused aneurism. The wall of the sac is formed of the condensed adjoining tissues, and the communication of its cavity with the artery is therefore through an actual opening in the wall of the latter. A traumatic aneurism is the type of this class, but most, if not all, large aneurisms would be included under the definition, rather than in class (*c*), because of the substitution of condensed connective-tissue in the wall for the distended external coat of the artery. The presence of a lining coat similar to the intima of the artery is not proof of the persistence of the latter; it may be of new formation.

II. Arterio-venous aneurism, formed by abnormal communication between an artery and a vein; subdivided into

(*a*) Aneurismal varix, in which there is no sac intermediate between the artery and vein; and

(*b*) Varicose aneurism, in which there is an intermediate sac.

III. Cirsoid aneurism (or arterial varix), formed by the general dilatation of an artery and its branches.

IV. Dissecting aneurism, formed by the effusion of blood between the coats of an artery after ulceration of the intima.

I. Common Encysted Aneurism (mainly Spontaneous).—The formation of a spontaneous aneurism appears to be preceded by a degenerative change in the wall of the artery by which both its elasticity and its power to resist a distending strain are diminished. This change is in the nature of an endarteritis, and consists in a hyaline degeneration of the intima and a disintegration of the elastic and muscular tissues forming the middle coat. It may begin without known cause or may follow the lodgement of an embolus or some mechanical injury to the vessel, as the application of a ligature,* or even, as in one case, prolonged digital pressure. Under the influence of the blood-pressure, increased at every contraction of the heart, the degenerated wall yields, and becomes stretched; if the degeneration has involved the entire circumference and a considerable length of the vessel, the dilatation is uniform (fusiform aneurism) or irregularly pouched; if only a small portion of the wall is involved, it expands and forms a pouch which communicates, either largely or by a narrow opening, with the lumen of the artery. The elongated forms, or dilatations, are common in the aorta, the pouched forms in the arteries of the limbs. In small, bud-like aneurisms the persisting three coats can be identified; in the larger ones they cannot be traced for more than a very short distance beyond the neck of the sac. It is reported that Haller produced aneurisms in frogs by dissecting away the outer coat of the artery (the mesenteric), but similar attempts made by Hunter upon the carotid and femoral of the dog were unsuccessful, although the dissection was carried so far that the color of the blood could be seen through the thin remaining portion of the wall.[1]

Examination of the wall of a sacculated aneurism of considerable size (Fig. 168) shows that it is composed of condensed connective-tissue, with a lining membrane in its inner surface that resembles the intima of an artery to this extent, that it has an epithelial surface of flat cells and a deeper structure of flat cells separated

* See cases quoted by Follin (Pathologie Externe, vol. ii., p. 339), in one of which three aneurisms formed after three successive ligatures, of which the first was in an amputation just above the elbow, the second of the brachial, to cure the first; the third, to cure the second; a fourth ligature, on the axillary artery, was not followed by dilatation. The case was Warner's, in the first half of the eighteenth century, and the aneurism was laid open in each operation.

by a fibrillary substance. A similar structure is found also upon the surface of thrombi, as after the ligature of an artery, and it must, therefore, be deemed not simply a distended intima, but rather a layer of new formation. Traces of the middle coat may be found at different parts of the aneurismal sac, especially in the neighborhood of its neck, where, indeed, they may form a continuous layer with that of the artery; but in the more distended portions of the sac they are entirely absent, and it appears to be well established that there is no hyperplasia of the muscular and elastic tissues which compose this coat, but that their elements undergo not only degeneration but also mechanical separation, and they have practically no share in the formation of the wall.

FIG. 168.—Aneurism of the Femoral Artery. The walls of the sac consist only of the *adventitia* (*a*) and *intima* (*b*); the *muscularis* (*c*) remains only at the entrance of the sac. (Weber.)

The new tissue may itself undergo fatty degeneration, or become atheromatous or calcified. As the sac enlarges it may become thinned at some point and burst, with escape of its contents into the adjoining tissues ("ruptured aneurism"); and when, in its growth, it reaches and presses upon firm, unyielding tissues, like bone, the latter undergo absorption. Bone disappears under this pressure by rarefaction; that is, a general rarefying osteitis is set up, characterized by the enlargement of its vascular canals, multiplication of the cellular elements and disappearance of the earthy salts, but without production of pus. Other tissues may become inflamed under the same irritation, and the inflammation may be plastic, with production of adhesions, or ulcerative. Thus, adjoining serous surfaces unite (pleura, pericardium, peritoneum), or rupture may take place through ulceration of the walls of the trachea or of the œsophagus, or of the wall of any other cavity that is pressed upon. These openings may be large or small, and may give rise to repeated small hæmorrhages, or may cause death instantly by a free one, either external or internal.

The growth of the sac takes place in the direction of least resistance, but this direction is determined rather by the distensibility of the wall itself than by the resistance of the surrounding parts; thus, the wall may be comparatively firm on the side adjoining a cavity, and growth may be slow in that direction, while at another point where it rests against bone the latter may be rapidly absorbed and even perforated, as is seen in the sternum, and this perforation will be followed by rapid enlargement of the aneurism through the opening. Aneurisms of the limbs seldom rupture through the overlying skin, probably because they receive treatment before their growth has reached such a point, but those of the thoracic aorta and innominate not infrequently end by ulceration of the skin and fatal external hæmorrhage. An aortic aneurism reaches the surface either by growth upward into the neck or through the sternum, or between the ribs to the surface of the chest. The absorption of the bodies of the vertebræ by thoracic or abdominal aneurisms gives rise to some of the most painful symptoms of this fatal and painful affection. In two cases quoted by Mr. Holmes from Dr. Gairdner the spontaneous opening of an aneurism through the skin was followed by the healing of the opening, and in one of them apparently by the cure of the disease; but such a result is so entirely exceptional that it deserves mention only as a surgical curiosity. When an aneurism has ruptured externally or internally, the progress in the immense majority of cases is from bad to worse, if the hæmorrhage is not immediately fatal. The bleeding may be arrested by syncope or by the plugging of the orifice by a clot, but it recurs again and again, and ultimately proves fatal unless the recurrence can be prevented by treatment.

The pressure of the growing tumor not only leads to the condensation and absorption of the tissues pressed upon, but it also causes much pain, either by stretching nerves or by provoking a neuritis, and it may interfere with the circulation of a part or limb by closing a vein or even an artery, and lead to gangrene.

The blood contained within an aneurism is usually in part liquid and in part clotted, and the inner surface of the wall of the sac is lined with layers of grayish opaque fibrin of irregular thickness and extent. These layers may be comparatively thin, or they may fill the greater part of the cavity. They are produced by gradual deposit of the fibrin on the wall, so that those layers that are nearest the wall are the oldest, and also the shortest, because the sac has usually increased in size since they were deposited. They occasionally undergo degeneration and break down into a granular detritus, forming small cavities filled with a pulpy mass. Ordinarily the connection between the wall of the sac and the adjoining layers of fibrin is one merely by contact, and there is no growth of tissue from the former into the latter. This seems to be true at least of all growing aneurisms, but in those that have undergone spontaneous cure, or have been cured by treatment, the development of new tissue is observed. This firm laminated fibrin is called the "active clot;" the soft, dark clot, or "passive clot," which is frequently found loose in the cavity of the sac, is probably a post-mortem formation in most cases.

The growth of an aneurism may be stayed, and a practical cure obtained, by the deposit of sufficient laminated fibrin to fill its cavity or thoroughly to protect its wall from the distending effect of the blood-pressure, and this is thought to be the mode of cure by most methods of treatment. It seems extremely improbable that this laminated fibrin is a later stage of a "passive" clot; there is every reason to think that it is gradually deposited as such by the blood in consequence of changes or peculiar conditions in the lining membrane of the sac, or in the rapidity of the circulation. Under ordinary conditions this deposition does not take place rapidly enough to effect a cure; it occurs at some parts of the sac and not at others, its union with the sac is slight and the blood can readily insinuate itself between the two at the edge of the layers, and as the sac enlarges fresh portions are created and left uncovered to undergo subsequent distention. If the conditions are modified by operative or other treatment that diminishes the volume and force of the stream of blood, time may be given to the tissues of the sac at the edge of the clot to become more intimately adherent to the latter, and thus to make the clot a permanent protection against further increase. This is effected by granulations from the lining membrane which spread into the clot and over its surface, making it, as it were, a part of the wall of the sac, binding down its edges, and covering it with a smooth epithelial layer. The union between the wall and the layers of fibrin appears to be very slight, and limited to those layers immediately adjoining the wall, and there is no evidence that new vessels extend from the wall or between the layers of the fibrinous clot. Some aneurisms, after a long period of rest and apparent cure, have begun again to pulsate and to enlarge, and this fact can be explained only on the theory of a simple mechanical obstruction that has persisted during the period of quiescence and has then yielded and allowed the re-entrance of blood, the insinuation of blood between the layers of fibrin and the wall.

A cure may also follow the sudden formation of a soft "passive" clot. This fact has only recently been demonstrated by examinations made after the rapid cure of aneurisms by the use of the elastic bandage. The first case is reported by Mr. Wagstaffe in the "Transactions of the London Pathological Society," vol. xxix., page 72, a popliteal aneurism cured a few months before the pa-

tient's death. At the autopsy the sac was found to measure two inches in length and one inch in diameter, and to contain a central blood-clot measuring one by one-half inch, and surrounded by fibrous tissue continuous with the sac and artery (see Fig. 169). This tissue was abundantly supplied with blood-vessels, and the artery was permanently closed above and below. The process I conceive to be as follows: In consequence of the arrest of the current of blood, whether by a distal plug, or by ligature, or by compression, the blood within the sac clots, and it probably does so more promptly than within normal vessels because of the character of the inner surface of the wall of the sac. This clot fills the sac and probably extends for a variable distance into the artery above and below the opening. This extension prevents the re-entrance of blood into the sac even if the obstruction that led to the formation of the clot is afterward removed, and the latter then undergoes those changes with which we are familiar in clots formed outside the body. It divides into two portions, a central, shrunken, firm clot, composed of corpuscles and fibrin, and an external layer of serum. The latter is absorbed by the neighboring tissues, and the sac correspondingly retracts, and its wall thickens by this retraction and possibly by a hyperplasia of its cellular elements provoked by the irritation excited by the clot. This irritation involves also the adjoining wall of the artery, as is proved by the changes that occur even in normal vessels into which clots have extended. The intima thickens and sends out cellular prolongations which perforate the clot and spread over its surface; these new cells soon constitute a completely formed and resistant plug structurally continuous with the wall of the artery, and provided with a smooth epithelial surface. The artery is now as completely and permanently closed on each side of the aneurism as if ligatures had been placed upon it there, and the clot is left free to undergo its natural retrogressive changes, and the aneurism is relieved from the distending pressure of the arterial stream. Complete absorption of the serum reduces the clot to less than half its original size, and this reduction is slowly carried further by molecular disintegration and absorption of the corpuscles and fibrin.

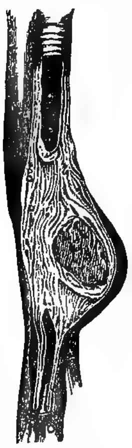

FIG. 169. — Section of an Aneurismal Sac containing a Clot surrounded by Organized Fibrous Tissue. (Wagstaffe.)

This conception of the process is supported by our knowledge of the changes which occur in blood that has clotted within the body under other circumstances, by certain clinical features observed in aneurisms that are undergoing or have undergone cure, and by the examination of specimens. Thus, in a case of popliteal aneurism, cured by the application of the rubber bandage, a non-pulsating area of fluctuation appeared in the sac a day or two after the operation, and slowly disappeared as the tumor diminished; there can be but little doubt that it was due to the pressure of serum exuded from the clot more rapidly than it was absorbed by the surrounding tissues. Again, in Mr. Wagstaffe's case above referred to, there was found a central blood-clot of comparatively small size, closely surrounded by the thickened sac, and the artery was permanently occluded by fibrous tissue continuous with its wall and with that of the sac; and in Dr. Reid's case (*Lancet*, August 5, 1876), the first one cured by the use of the elastic bandage, a similar condition of the parts was found: a central blood-clot, dark in color, and of cheesy consistency; a contracted but thin sac with a few partly adherent layers of laminated fibrin; and the artery occluded by fibrous tissue for a distance of two and a half inches above the sac.

The transformation of an obliterated aneurism into a blood-cyst after many years has been observed in one case, which is apparently unique. It is reported by Reinhold ("Inaug. Dissert.," Marburg, 1882; abstract in *Centralblatt für Chirurgie*, 1882, p. 571). It was a traumatic varicose aneurism of the popliteal artery and vein successfully treated by ligature of the femoral artery and compression of the sac. Nine years afterward a large tense cyst formed, containing crystals of cholesterin and hæmatin, and suppurated after multiple punctures; it was then laid open, and several old blood-clots and a few calcified fragments were turned out.

Causes.—Anything which reduces the power of resistance possessed by the arterial wall below what is sufficient effectively to oppose the distending force of the blood may be an immediate or a predisposing cause of aneurism. A sudden increase of intravascular pressure may combine with pre-existing weakness of the wall to produce an aneurism, but in the great majority of cases the change which leads to this production lies in the wall alone. Mr. Holmes quotes two cases in which the formation of an abdominal aneurism appeared to have been the direct consequence of the emotion experienced by a criminal on receiving a severe sentence. Weakness of the wall may be limited to a single large or small area, or may exist at many points, with the production of a corresponding number of aneurisms. This latter condition is termed the aneurismal diathesis, and although the affection is usually single, as many as sixty-three aneurisms have been found in one individual. The weakness of the wall is the result of change in the inner, and especially the middle coats of the artery, and this change may be the hyaline degeneration above described, or the one known as atheroma. Among the predisposing causes, therefore, must be counted all those which lead to degeneration of the arterial wall. The statistics collected by Mr. Crisp show that of 551 spontaneous aneurisms of all kinds, only 2 were of the pulmonary artery, 175 of the thoracic aorta, 59 of the abdominal aorta, 137 of the popliteal artery, 66 of the femoral, 24 of the carotid, 23 of the subclavian, 20 of the innominate, and 18 of the axillary. The disease is most common between the ages of thirty and fifty years, and is very rare in childhood; cases have been operated upon at eight and nine years. Broca claimed that the liability to aneurism increased with advancing years in the arteries above the diaphragm, and diminished in those below it. Aneurisms of the arteries of the extremities are much less frequent in women than in men, but there appears to be no such difference as regards internal aneurisms. This unequal distribution as regards the artery, the age, and the sex, indicates some of the causes, both general and special. Among the general causes are habits of life and peculiarities of constitution, which increase the arterial tension or diminish the strength of the arterial walls; the special ones are anatomical peculiarities and local lesions, changes, and injuries.

The habits of life which act as predisposing causes are excess in the use of alcoholic drinks, and occupations which call for the exertion of much muscular effort. The influence of syphilis has been alleged, but not proven, and the same is true of its mercurial treatment. The gouty or rheumatic diathesis predisposes to it. The influence of muscular effort, so far at least as regards external aneurisms, is shown by the greater prevalence among males than among females, and the greater frequency during the prime of life, notwithstanding the fact that degenerations of the arterial walls are more common in advanced life. Follin quotes in support of the influence of alcohol a remarkable statement made to him by the Dublin surgeon, Colles, to the effect that while the Father Mathew Temperance Societies flourished in Ireland, aneurisms were much less frequently seen than before or since that time.

The anatomical peculiarities which influence its occurrence are changes in the direction of an artery (as the arch of the aorta), normal enlargements of its calibre (as at the upper end of the carotid), bifurcations, and the neighborhood of joints which are habitually and violently extended and flexed (as the knee and hip). The local changes which are to be regarded as exciting causes are the changes already described as occurring in the arterial wall, and other changes or injuries which diminish its power of resistance or break its continuity. Thus the

sharp edge of a calcified atheromatous patch may cut through the intima and admit the blood into the rent, with the subsequent formation of a real aneurism, or of the variety known as dissecting aneurism. Or the middle coat may be ruptured by being overstretched, and the part thus weakened will be expanded to form an aneurism; or ulcerative inflammation outside the vessel may weaken, or even perforate its wall, leading in the former case to the formation of a typical aneurism, and in the latter, to the transformation of an abscess into an aneurism. Or, rarely, the process set up by a ligature upon an artery may extend beyond what is needed for the sealing of the vessel, and so weaken the adjoining portion by modifying its middle coat that it yields under the pressure of the blood and expands into an aneurism. Or an embolus may lodge in an artery and lead to the same result by the same process; this seems to be especially probable when the embolus has formed during ulcerative endocarditis, and the explanation is to be found in the septic or virulent qualities thought to be then possessed by the embolus. Four cases of this kind were reported by Dr. James F. Goodhart, in the "Transactions of the London Pathological Society," 1877, vol. xxviii., p. 98; in three of them the aneurism occupied the middle cerebral artery, or one of its branches, in the others the posterior cerebral artery.

Symptoms and Progress.—When an aneurism forms suddenly by rupture or perforation of an artery, or in consequence of a violent effort or emotion, its formation is accompanied by sharp pain, and the more or less prompt appearance of a tumor, if it is so situated that a tumor is recognizable. But ordinarily the formation is slow, and the patient's attention is first attracted by the presence of a tumor. This is situated in the line of an artery, is not adherent to the skin, is slightly movable, smooth, and regular in outline, usually globular or ovoid, soft and compressible, and pulsates synchronously with the heart. If steady pressure is made upon it, its size may be more or less diminished while the pressure is made, but it immediately regains its former volume when the pressure is removed. If it is grasped between the thumb and fingers or between the two hands, the pulsation is found to be expansile, that is, the fingers or hands are pushed apart by it, not simply lifted by it. If the ear is placed upon it a sound is heard corresponding to the pulsation; this is the *aneurismal bruit*, and while it may vary somewhat in character in different cases, it is usually harsh rather than soft or blowing; it may be limited to the time occupied by the pulsation or may extend over the entire interval from the beginning of one pulsation to that of the next. If pressure is made upon the artery above the tumor the latter diminishes somewhat in size, and the pulsation and bruit cease. The pulsation in the distal branches of the artery may be normal or diminished, and if the tumor presses upon the corresponding vein, the limb may be œdematous and swollen. The compressibility and softness of the tumor are modified by the amount of laminated fibrin within the sac.

In thoracic and abdominal aneurisms many of these signs are unrecognizable, because of the inaccessibility of the tumor to palpation. The objective symptoms of thoracic aneurism are abnormal dulness on percussion over the region occupied by it, an impulse communicated by it to the sternum or ribs, aneurismal bruit, and possibly the presence of a tumor at the root of the neck or on the front of the chest. Other symptoms are pain and those produced by pressure on various adjoining organs: dysphagia, diminished respiratory murmur on one side, alteration of the voice by pressure on the recurrent laryngeal nerve, and perhaps differences in the pulse when the two carotids or the two radials are compared. In abdominal aneurism the size, shape, and peculiarities of the tumor can sometimes be recognized.

Pain may accompany aneurism, when once formed, and is due either to stretching of nerves or to pressure upon, and inflammatory processes excited in, them and other adjoining tissues.

The tendency of an aneurism is to increase in size; for the absence from the wall of the sac of a muscular coat, the most efficient agent to withstand the expanding blood-pressure, leaves the wall unprovided with any tissue able successfully to oppose this pressure. The growth may be rapid or slow, according to circumstances, chief among which are the size of the opening by which the sac communicates with the artery, the firmness of the surrounding tissues, and the readiness with which the blood in the aneurism clots or deposits laminated fibrin upon its wall. The enlargement may be uniform, or more marked at some points, and more rapid at some times than at others.

Its natural tendency is to spread and finally to rupture, either by gradual weakening of its wall or by ulceration into a natural adjoining cavity or through the skin. As it approaches the surface the skin becomes tense, adherent, and inflamed, and may ulcerate or become gangrenous. The subcutaneous tissues may be similarly affected, and thus an abscess may form between the sac and the skin, into which the aneurism may rupture either before or after the abscess has opened externally. The inflammatory process outside the sac has been thought to favor coagulation of the blood within it, and thus to lead to a temporary or even a permanent arrest of the disease; but ordinarily free hæmorrhage follows the rupture and requires extreme measures for its arrest, if indeed arrest is possible.

The most favorable, and one of the possible terminations of aneurism, is its *spontaneous cure* by coagulation of the blood within it. Some of the conditions which provoke or favor this occurrence have already been referred to. They may all be classified under three heads: 1, Those which favor clotting in the sac by retardation or arrest of the current through it; 2, those which increase the coagulability of the blood; 3, those which provoke coagulation through change in or about the wall of the sac.

1, *Retardation or arrest of the current;* and 2, *Conditions which increase the coagulability of the blood.* It has been abundantly proved, both clinically and by the study of specimens, that total arrest of the current in the sac is not necessary for the coagulation of the blood contained in it, but that a partial arrest or slowing, effected by influences acting upon the general circulation or only upon the blood occupying portions of the sac, may either begin the process or promote the extension of the process after it has been begun. Most aneurisms of any size contain laminated fibrin adherent to some portion of the wall, and some are found completely filled with it, or so nearly filled as to leave only a small canal through which the current is maintained. When these clots are small, they habitually occupy those portions of the sac in which the circulation was apparently the least rapid, and it has been observed that the adoption of measures or the occurrence of changes which have diminished the rate of flow, or the quantity of blood passed through the vessel upon which the aneurism is situated, has been followed by a gradual cure through the deposition of fibrin. The permanency of such a cure depends upon the maintenance of the reduction in the rate or volume of the blood-current, or upon the creation of such relations between the clot and the wall of the sac that the former becomes a permanent part of the latter, and protects all portions of it from the action of the expanding force of the blood. These relations consist in the formation of a membrane by proliferation of the cellular elements of the intima of the artery, and the spread of this membrane over the edges, and perhaps over the whole of the exposed surface of the clot, in such a way as to prevent the insinuation of the blood between the clot and the wall, and to give a smooth epithelial surface over which the blood passes without depositing additional fibrin.

The causes of retardation or arrest are various. They may be found in the shape of the sac, in the general condition or habits of the patient, or in special modifications of the flow through the artery itself.

Pouched sacs, or sacs with small necks, are more favorable to the occurrence of clotting than fusiform dilatation or sacs with large, free openings, because the blood that enters does not immediately leave them, it forms a sort of eddy beside the general stream in which the current is slow or almost nil.

Of the causes arising in the general condition or habits of the patient, the first and most important is continuous rest in bed for weeks or months, combined with a light, unstimulating diet. Others, which may also act by increasing the coagulability of the blood, are bleeding, either large or small and repeated, and the internal use of various drugs, such as digitalis, tartar emetic, veratrum viride, iodide of potassium, acetate of lead, ergot, and the chloride of barium. Cures have followed the use of each of these measures, alone or in combination, but it is not always easy to determine how much credit is to be awarded to the treatment in any one case.

Retardation or arrest of the flow may also be caused by obstruction of the orifice of the sac, if it is small, or of the artery above or below the aneurism. The most common agency in producing this change is the detachment of a fragment of fibrin from the wall of the sac and its lodgment in the neck of the sac, or in the artery below. The latter occurrence is habitually accompanied by severe pain in the limb, and is evidenced by arrest of pulsation in the distal branches of the artery. A cure by this mechanism has been observed a number of times, and it forms the basis of a method of treatment suggested by Sir Wm. Ferguson, in which the forcible detachment of a clot from the wall is sought to be effected. If the detached clot is small, it may lodge on the spur of a bifurcation and then grow in size by additional deposits of fibrin until it obstructs one or both of the branches, and in such a case retardation precedes complete arrest.

This possibility of the detachment of small clots and their passage into the distal branches of the artery, involves the risk of other changes far different from the cure of the aneurism. The arrest of the circulation may lead to gangrene of the lower portion of the limb, total or partial, according to the seat of the obliteration; and if the aneurism is situated upon the arch of the aorta or one of the vessels going to the head, the emboli may lodge in the vessels of the brain and cause death promptly. I once saw a surgeon examine a patient with an aneurism of the aorta that had perforated the sternum and formed a large tumor over it; he made pressure upon the tumor and reduced it through the opening; as he did so, the patient was seized with convulsions and became unconscious, and after his death, on the following day, the brain, kidneys, and spleen were found filled with emboli, fragments of the laminated clot that had lined the wall of the projecting tumor.

When there is merely retardation of the current the cure takes place by the gradual deposit of laminated fibrin; and when there is total arrest it takes place probably by coagulation in mass of all the blood within the sac, and the subsequent shrinking of the clot and sealing of the vessel by the production of fibrous tissue, as has been described above.

Another alleged cause of retardation of the stream is pressure of the tumor upon the proximal portion of the artery, but no cases have been reported in which this mechanism has been demonstrated. Its supposed possibility rests upon theoretical grounds alone, and while it may be admitted as a possibility, there is but little reason to believe it has ever taken place.

3. *Conditions which provoke coagulation through change in or about the wall of the sac.* Inflammation of the sac, or of the tissues immediately overlying, it is alleged by Broca and others to be a cause of coagulation within it and of consequent cure. Mr. Holmes thinks this has never been demonstrated, and attributes the cure in the cases that have been cited in support of the theory to impaction of a clot. There is no doubt but that inflammation about an artery or vein can and does often lead to the formation of a thrombus within the vessel, but the conditions in an aneurismal sac are so different that it is perhaps unjustifiable to argue from a supposed analogy.

The sudden formation of a soft clot within an aneurism may excite inflammation and suppuration of the sac, with subsequent rupture. In a few cases this has been followed by a cure, but the cure must be attributed to the obstruction of the vessel, either by the original clot previous to the rupture, or by a secondary clot after the hæmorrhage that has followed the rupture.

In like manner, tardy suppuration may follow cure, and after an aneurism has remained quiescent and shrunken, in fact cured, for months or even years, such suppuration may lead to the casting out of the clot in whole or in part.

Changes in laminated fibrin after the cure of an aneurism are slight and gradual, and rarely amount to more than a diminution in size by shrinking; sometimes the fibrin becomes soft, and sometimes lime salts are deposited in it. A unique case of late transformation into a blood-cyst has been mentioned above.

Diagnosis.—The typical symptoms of aneurism are the existence of a more or less well-defined tumor that pulsates synchronously with the beat of the heart, has a distinct intermittent bruit, and diminishes in size while pressure is made upon it or upon the proximal portion of the artery from which it arises. But these signs may be variously modified or abolished by the varying conditions that have been above described, or may be undemonstrable because of the position of the tumor, or may be simulated by those of other affections. An additional sign is sometimes found in a difference in the character of the pulse in the distal branches of the artery when compared with that in the branches of the corresponding artery of the other side, a difference that may be recognized by the finger, but much more certainly by the sphygmograph.

The diagnosis of aneurism of the thoracic aorta is made by recognition of an abnormal area of dulness, pulsation, and bruit, perhaps with dysphagia, hoarseness, diminished respiratory murmur on one side, interference with the return venous flow from the neck, pain in the chest, and perhaps differences in the radial or carotid pulse. The differential diagnosis with aneurism of the innominate may be difficult or impossible, for an aneurism of the arch of the aorta frequently presents as a tumor in the neck, and may even extend into the posterior cervical triangle.

In abdominal aneurism of the aorta, cœliac axis, or mesenteric arteries, the only symptoms may be the indefinite ones of pain and pulsation, with an ill-defined tumor, and it may be impossible to determine whether the tumor itself pulsates or whether the pulsation is not merely communicated to it by the underlying aorta. If it can be grasped and lifted up, the diagnosis can be made, for in such case the pulsation will persist if it is an aneurism, and will cease if it is not. This exploration is not devoid of danger, since the handling may cause the sac to burst, as in a case in which the patient, himself a physician, sought to prove to the attendants that the tumor was a mass of hardened fæces which could be lifted away from the aorta; the attendants retired to an adjoining room for consultation, and on their return found the patient dying. The sac had been ruptured.

The symptoms in external aneurism may be modified by the partial or complete consolidation of its contents, or the temporary obstruction of its orifice, either of which occurrences may greatly diminish or arrest the pulsation and bruit.

The affections with which an aneurism is most likely to be confounded are solid or liquid tumors overlying an artery and very vascular tumors lying in or near the course of a large artery. In all, the common signs are a pulsating tumor with bruit, and the ability to arrest the pulsation and bruit by pressure on the artery. The pulsation of an aneurism is *expansive*, the tumor enlarges laterally at each pulsation; that of an overlying tumor is a simple lifting of the entire mass, but this difference cannot always be recognized with certainty, for if the fingers cannot be pressed down to the widest part of the tumor, the simple rising of the sloping sides of the globular mass between them forces them apart, and simulates lateral expansion. A bruit may be caused in an artery or vein by pressure upon it; in a vein such a bruit is harsh and continuous, in an artery it is intermittent and more "blowing" in character than that of an aneurism.

In the case of a suspected liquid collection simulating aneurism the diagnosis may be aided by aspiration with a fine needle. An aneurism has been mistaken for an ab-

scess frequently enough to make great caution necessary in the diagnosis and treatment of any supposed abscess lying in the course of a large artery; the fingers should always be pressed deeply into the swelling in search of pulsation, and even if an abscess is certainly present, it should be remembered that it may have formed over an aneurism.

As pulsation and bruit have their origin in the stream of blood brought by the artery, pressure upon the proximal portion of the vessel will arrest them, whether they belong to an aneurism or are simply communicated through a tumor. Vascular tumors, especially those arising from bone, often have well-marked pulsation and bruit; but their pulsation is less "heaving" or "massive" than in aneurism, and the bruit is rarely well marked. The diagnosis may be extremely difficult, or only possible by the aid of exceptional explorations. In a case of large pulsating tumor of the gluteal region, under the care of Professor Henry B. Sands, in the Roosevelt Hospital, New York, in 1880, the diagnosis of aneurism was made by passing the hand into the rectum, and thus learning that the internal iliac artery was enlarged, the enlargement increasing from above downward to the sacro-sciatic notch. The frequent presence in vascular tumors of large collections of blood contained within sacs formed by the rupture or dilatation of capillaries or small vessels increases the resemblance to an aneurism.

An aneurism which has just ruptured into the adjoining tissues does not pulsate, and may have no bruit; under such circumstances the diagnosis must be made by the history of the case, the pre-existence of a pulsating tumor, and the cessation of the pulsation coincidently with a marked change in the shape and size of the tumor. In like manner, where an artery has just been ruptured or perforated and the blood has been effused into the adjoining tissues, pulsation and bruit are not present until after the effusion has become circumscribed by a distinct firm wall composed of the condensed tissues ("traumatic aneurism" or "ruptured artery").

For the differential diagnosis of arterio-venous aneurism and cirsoid aneurism or arterial varix, *vide infra*.

Prognosis.—The gravity of the prognosis varies with the artery involved, and the size and character of the aneurism. In internal aneurisms the prognosis is very grave; in external aneurisms it is commonly much less so, since in most of them suitable treatment offers a reasonable hope of cure.

Treatment.—*Medical treatment:* The medical treatment of aneurism, especially of internal aneurisms, which are commonly regarded, and with much reason, as practically incurable, consists in absolute rest in the recumbent position, maintained for weeks or months, combined with a restricted diet, and aided, perhaps, by the use of various drugs. The absolute rest and the low diet are unquestionably the most efficient part of the treatment, and the drugs, even those for which most has been claimed, are only adjuvants of uncertain and often very doubtful utility. Systematic treatment of this kind dates from the time of Valsalva, and even in his hands the rest was subordinate to repeated venesection, which he carried to such an extent that rest in bed was a matter not of choice, but of necessity. This active depletion was never regarded with much favor, and as it was long deemed an essential part of treatment by rest the latter shared in the disfavor of its associate, and patients affected with internal aneurisms were habitually looked upon as beyond the reach of art, and the interference of the physician was restricted to relief of pain and the occasional employment of drugs from which it was thought some benefit might possibly accrue. To Mr. Tufnell,[2] of Dublin, belongs the credit of demonstrating the value of absolute rest in bed and restricted diet in promoting a cure or affording great relief. He insists upon the absolute maintenance of the recumbent posture, and restricts the amount of food to about eight ounces of solid food and six ounces of liquid daily, the solid food being bread, butter, and meat, the liquid milk and a little claret wine.

Of drugs, the iodide of potassium has been most employed, in doses of from half an ounce to one ounce daily. A number of cases of aortic aneurism apparently cured or greatly relieved by its use have been reported.

Digitalis, veratrum viride, and ergot have also been used, with the object of slowing the circulation; occasional supposed cures or temporary arrests by their agency have been reported, but they are not regarded with favor by the authors of systematic treatises on the subject. Ergot is given internally in the form of the fluid extract, or subcutaneously as ergotine. Mr. Holmes regards the acetate of lead as offering the best promise. Dr. F. Flint[3] reported a case of aneurism of the abdominal aorta apparently cured by the use of the chloride of barium in doses of from one-fifth to three-fifths of a grain three times daily for about five months, after Tufnell's method had entirely failed. The most rapid improvement coincided with the smallest dose.

Surgical methods of treatment may be grouped in three classes:

1. Radical obliteration of the sac by opening it and tying the artery immediately above and below its point of communication with the aneurism. This is known as the "old method" or the "method of Antyllus."

2. Permanent or temporary arrest of the afferent stream at a point on the proximal side somewhat removed from the aneurism.

a. Ligature of the artery (Anel's method, or the Hunterian method).

b. Metallic ligature; artery constrictor.

c. Compression of the artery; direct, indirect, digital.

d. Esmarch's elastic bandage.

e. Flexion of the limb.

3. Permanent arrest or obstruction of the stream on the distal side.

a. Distal ligature.

b. Manipulation to produce an embolus or impacted clot.

4. Rapid coagulation of the blood in the sac (with or without temporary arrest of the stream).

a. Coagulating injections.

b. Introduction of solid bodies.

c. Galvano-puncture.

1. The "old method" (or the method of Antyllus). The aneurisms with which the ancient surgeons had mainly to deal, or at least those to which operative interference was mainly limited, were traumatic aneurisms at the bend of the elbow following venesection. It has been claimed for them that they knew and practised the method of cure by ligature of the artery in continuity above the sac, but Hodgson's statement, which is quoted by Mr. Holmes in support of this claim, does not fully and accurately present the practice. Ligature of the brachial artery "three or four finger-breadths below the axilla" was indeed recommended by Aëtius in the fifth century, but only as a preliminary to the opening of the sac at the elbow and the application of another ligature there, and solely with the object of preventing hæmorrhage during the operation proper. The main object of treatment was to remove the clot, which was thought to be a source of danger, and to prevent subsequent hæmorrhage by obliterating the artery or closing the opening by which it communicated with the sac. The operation appears to have fallen into disuse and not to have been revived until about the seventeenth century, when it was again used with various modifications, but at first only in traumatic aneurisms at the elbow. It appears to have been first used in popliteal aneurism by Keyslère; the date of his first operation is not known, his second and third were done in 1747 and 1748 respectively. His first three cases were successful; the fourth died.

The method of operation, as practised in popliteal and brachial aneurisms until the end of the eighteenth century, was to control the artery by a tourniquet or the fingers, divide the sac by a longitudinal incision, turn out the clots, find the point of communication with the artery, isolate the latter, and tie it above and below the opening. The cavity was then packed with lint and allowed to fill by granulation.

The difficulties and the dangers were great. The opening into the artery was often deeply placed and difficult of access, so that the external incision needed to be very long (ten inches, in a case of popliteal aneurism), and after the opening had been found the isolation of the artery was difficult; it was recommended to seek for it with a catheter or probe, and, after having found it, to introduce this instrument into it and use it as a guide and help in denudation, a suggestion that has recently been revived and practised in similar cases.

The results in popliteal aneurism were so bad that most surgeons appear to have preferred amputation. Pott says he had tried it more than once or twice himself, and had seen it tried by others, but always with a fatal result; and, as Mr. Holmes points out, the immediate acceptance and substitution of the Hunterian operation, which was itself nearly as fatal as amputation of the thigh, shows that the mortality after the old operation must have been frightful. Secondary hæmorrhage on the fall of the ligatures was frequent, and so, too, was gangrene of the distal portion of the limb, probably because of the pressure of the lint with which the cavity was stuffed, or of injury to the vein, or of its inclusion in the ligature.

The causes of the bad results are not far to seek: difficult and deep dissection, a large wound, imperfect hæmostasis during the operation, the ligature placed upon an unhealthy portion of the artery, and officious and dangerous modes of dressing make a group of hostile conditions so numerous and powerful that it is not strange so few escaped with their lives. Modern improvements in operative methods, anæsthetics, the catgut or antiseptic ligature, and antiseptic dressings have brought a much larger measure of success in cases even less promising than the average, and the "old method" is still in use and gives fairly good results in cases in which the Hunterian method is impracticable, and, indeed, it even receives the preference in some others. Syme, after a long experience, which included some of the most brilliant and successful operations upon arteries recorded in the history of surgery, formally declared his preference for the old method over the Hunterian, except for aneurisms of the popliteal, femoral, and carotid arteries. The cases in which it has recently been used with success, and for which it is formally recommended[4] after lesser measures have failed, are some traumatic aneurisms, aneurisms of the subclavian, axillary, and gluteal arteries, also after rupture of the sac, as a means of avoiding amputation (Holmes), when the diagnosis is uncertain and the tumor may be cancerous, and when the aneurism has recurred after apparent cure by ligature. Three successful cases of the kind last mentioned have been reported within the last eight years, Annandale, in the *Lancet*, April 22, 1876, p. 597, and in the *British Medical Journal*, April 17, 1880, p. 587; and Dr. Jos. C. Hutchison, in the *American Journal of the Medical Sciences*, October, 1880. The first and third were femoral aneurisms recurring six months and four years respectively after ligature of the external iliac; the second recurred seven years after ligature of the femoral. I quote Dr. Hutchison's case briefly to indicate some of the operative difficulties that may be expected.

A rubber tube was applied around the thigh below the tumor, and the abdominal aorta compressed by a tourniquet. Although pulsation in the tumor was thereby arrested, yet blood flowed freely from a vessel which opened on the inner side of the sac, supposed to be the internal circumflex artery; the bleeding was arrested by the introduction of a rubber bougie into the orifice of the vessel. "The artery was secured with much difficulty by seizing its mouth on either side with tenacula and drawing it forward, the bougie still acting as a plug; a ligature was thrown around it and tightened as the bougie was withdrawn." The ligature came away on the twenty-fourth day, and the patient made a good recovery, although gangrene seemed imminent at one time.

The frequency of secondary hæmorrhage was thought by Hunter to be due to the diseased condition of the arterial wall near the sac, where the ligature was applied, and this has always been deemed one of the most weighty reasons for preferring the Hunterian method, in which the ligature is placed upon a more distant and presumably healthy part of the artery. It must be remembered, however, that secondary hæmorrhage was much more common in former days, after all operations in which a large artery was tied, than it is at present, when it has become very rare after ligature with catgut or aseptic silk, and that arteries so degenerated, or even calcified, that they broke when the ligature was drawn tightly, have remained securely closed by slighter pressure, and the wounds have healed without accident. I am therefore inclined to believe that a catgut ligature can be applied to the degenerated, and even dilated, portion of an artery adjoining an aneurism with sufficient prospect of success to justify the measure when other methods are inapplicable or exceptionally dangerous. The catgut ligature goes far, I think, to justify the preference given by Syme to the old operation in axillary and gluteal aneurisms, and, by extension, in other exceptional cases.

A possible disadvantage is that the clot on the proximal side may not be sufficiently large and permanent to protect the already weakened wall from the pressure still exerted by the blood, and that consequently a second aneurism may form above the ligature. What the probability of such an occurrence is, I have no means of estimating.

In traumatic aneurism the objection of a changed condition of the adjoining arterial wall cannot properly be urged, and there remain only those of the greater difficulty of the operation and the greater size of the wound.

Syme's method of operating when the artery could not be controlled on the proximal side of the sac was to make an incision into the tumor just large enough to admit his finger, with which he then felt for and compressed the opening in the vessel. If he could not thus find the opening, the incision was enlarged and a second and third finger, and in one case the entire hand, says Mr. Holmes, introduced. When the opening was found and commanded, he enlarged the incision, turned out the clots, and denuded and tied the artery above and below.

2. Permanent or temporary arrest of the afferent stream at a point on the proximal side somewhat removed from the sac.

a. Ligature by Anel's method, or the Hunterian method. The question of priority in the introduction of the method of tying the artery above the sac, as now practised, has given rise to much controversy, but must here be dealt with very briefly. It is claimed by the French for Anel, a French surgeon practising in Rome in 1710, and by the English for John Hunter in 1785. The reader who is curious in the matter is referred to Broca ("Des Anévrysmes," Paris, 1856) and to Holmes ("A System of Surgery") and to a paper by the writer in the *New York Medical Journal*, November, 1, 1884. The facts, in brief, are as follows: January 30, 1710, Anel treated a traumatic aneurism at the bend of the elbow by tying the artery close above the sac without opening the latter, and thereby effected a cure. The patient was a priest. The case gave rise to much discussion, the account of it was reprinted in several books and journals, and the method was subsequently used before 1785 in at least three other cases, in one of which the ligature was applied about two inches above the sac (Broca, p. 446). June 22, 1785, Desault (after having a few months previously sought to cure an axillary aneurism by compression of the subclavian) treated a popliteal aneurism by tying the artery, "immediately below the ring of the third adductor," that is, at the point where the femoral artery ends and the popliteal artery begins; the aneurism was cured, and the patient died eleven months later of disease of the lower end of the tibia. December 12, 1785, John Hunter treated a popliteal aneurism by tying the femoral artery and vein "rather below the middle of the thigh." * In

* Everard Home, in Transactions of a Society for the Improvement of Med. and Surg. Knowledge, London, 1793, p. 148. This appears to be the first official publication of the case: the paper is not dated, but it is printed between two which are dated September, 1789, and September, 1790, respectively.

the following March, 1786, Desault, having knowledge of Hunter's case, operated upon another and tied the artery at a still higher point, dividing the sartorius to expose it.

Hunter repeated the operation four times within the four years following his first case, tying the vein as well as the artery, except in the last two; Desault died shortly after his own second case.

These facts are not disputed; the controversy has arisen over the principles which are thought to have led, in the minds of the different operators (Anel, Desault, and Hunter), to the adoption of the method.

It is claimed by the English (Guthrie, Holmes) that Anel did not know what he was doing, did not appreciate the importance of the method, the mode by which it effected a cure, and its applicability to other aneurisms than those at the elbow, and that, as he used it, it was radically defective in placing the ligature too close to the sac and without the intervention between the two of any collateral branch given off from the artery; that, in short, it was a mere happy chance, stumbled upon without reflection, and passed without appreciation; that Desault's, in like manner, was a mere experiment, but that Hunter's was the result of profound reflection and reasoning upon the nature of the disease and the manner in which coagulation of the blood in the sac is effected, and especially of his knowledge of the fact that complete shutting off of the current from the sac was not necessary. The original reports, on examination, do not appear to justify any of these claims, which seem to have no more solid basis than ignorance of what Anel and Desault really thought, and the crediting of Hunter before his operation with knowledge which he obtained at a later period. Hunter's identification with the operation was in large part the result of his exceptional authority at the time, the publicity which attended or was given to the act, the frequent repetitions, and the generalization which promptly followed it, and of the great ability with which he set forth the principles upon which it rested. These, in themselves, are an ample title to recognition and respect, and Hunter's glory may well be left to rest on them without robbing others of their just due.

Three months after Desault's first operation, and three months before Hunter's first operation, at a consultation held in London on a case of femoral aneurism as large as an orange, in which Hunter took part, all agreed that it was impossible to resort to the operation ordinarily practised upon aneurisms, and recommended pressure on the artery in the groin; the attempt was made, and abandoned because of the pain it caused. It is apparent that at this time Hunter had not developed his method. The arguments that led Hunter to tie the femoral artery for popliteal aneurism, according to Home, his pupil, assistant, and reporter (loc. cit., p. 145), were "that the disease often extends along the artery for some way from the sac; and that the cause of failure in the common operation arises from tying a diseased artery, which is incapable of union in the time necessary for the separating of the ligature." . . . "If the artery should afterward give way [if tied just above the sac], there will not be a sufficient length of vessel remaining to allow of its being again secured in the ham. To follow the artery up through the insertion of the triceps muscle, to get at a portion of it where it is sound, becomes a very disagreeable part of the operation; and to make an incision upon the fore part of the thigh, to get at and secure the femoral artery, would be breaking new ground, a thing to be avoided, if possible, in all operations. Mr. Hunter, from having made these observations, was led to propose that in this operation the artery should be taken up in the anterior part of the thigh, at some distance from the diseased part, so as to diminish the risk of hæmorrhage and admit of the artery being more readily secured, should any such accident happen. The force of the circulation being thus taken off from the aneurismal sac, the progress of the disease would be stopped; and he thought it probable that, if the parts were left to themselves, the sac with its contents might be absorbed and the whole of the tumor removed; which would render any opening into the sac unnecessary."

It is plain, from this, that Hunter's idea in seeking the artery at a higher point was simply to avoid secondary hæmorrhage and to make its treatment, if it should occur, easier; and the extent to which this idea preoccupied his mind is shown in the strange additional precautions he took in the matter of the ligature itself. He tied the artery with four ligatures, "but so slightly, as only to compress the sides together. . . . The reason for having four ligatures was to compress such a length of artery as might make up for the want of tightness, it being wished to avoid great pressure on the vessel at any one part."

According to Mr. Holmes, "the great merit of Hunter consists in his having seen, *first*, that it was not necessary to turn the clots out of the aneurismal tumor; . . . and, *second*, that it was not necessary to stop the circulation through it absolutely, but only, as he said, 'to take off the force of the circulation.'" The first of these was certainly appreciated by Anel and Desault, for they saw their patients get well; the second is difficult to explain, if it is based upon the fact that the ligatures were tied loosely, for they certainly were intended to, and did, cut out, and therefore occluded the artery entirely; and in Hunter's subsequent operations he used a single ligature and tied it tightly, so that if this was his opinion and object at first, he subsequently abandoned it. The idea, moreover, is expressed by Home (loc. cit., p. 156) as a conclusion drawn from what was found at the autopsy eleven months later: "The conclusion to be drawn from the above account appears a very important one, viz.: That simply taking off the force of the circulation from the aneurismal artery is sufficient to effect a cure of the disease, or at least to put a stop to its progress." It seems much more reasonable to infer that Hunter's object in tying the ligatures loosely was to give the artery more time to become sealed before the ligature cut through. (See the first quotation from Home given above).

The statement has been generally quoted as meaning that Hunter proposed to leave one or more collateral branches between the ligature and the sac, but there is nothing in the account of the operation or of the autopsy to justify such an opinion. "The femoral artery was impervious from its giving off the arteria profunda as low as the part included in the ligature, and at that part there was an ossification for about an inch and a half along the course of the artery. . . . Below this part the femoral artery was pervious down to the aneurismal sac, and contained blood, *but did not communicate with the sac itself, having become impervious just at the entrance* [italics mine]. . . . The popliteal artery, a little way below the aneurismal sac, was joined by a small branch, very much contracted, which must have arisen from the profunda, or the trunk of the femoral artery." This is the only collateral branch mentioned, and I do not see how the conclusion can be avoided that even if the phrase "to take off the force of the circulation" meant any more than "to arrest" or "cut off" the circulation, it meant only that the artery was left containing blood, and that this blood was in communication with that brought to the lower part of the same artery by collaterals coming from above the ligature. It would be interesting, too, to know by what "profound reasoning Hunter excogitated the principle" (Holmes) of including the vein in the ligature with the artery.

Even if Hunter afterward declared the presence of a collateral branch between the ligature and the sac to be a favorable condition, it does not affect the original conception; and furthermore, the existence of such a collateral branch is not essential to the method, and it is not found when the carotid or femoral is tied, or in some cases when the external iliac or subclavian is. In short, the method as now employed is to place the ligature at the nearest convenient point, sufficiently far above the sac to find the artery probably healthy; and the claim that has been made that complete arrest of the circulation is more dangerous than partial arrest, because it leads to the formation of a passive clot which is likely to provoke suppuration of the sac, has been proved, especially by the experience with the Esmarch bandage, to be incorrect, or at least the danger of exciting suppuration is much less than was claimed.

Aneurism.

The changes within the sac by which a cure is effected after ligature, are similar to those above described as effecting a spontaneous cure. The closure of the artery relieves the sac from all expanding pressure, except the slight amount which may be exerted by the blood that comes into the artery below the sac or between it and the ligature through collateral branches. The pressure being removed, the sac shrinks, the blood within it either coagulates in mass, forming a dark passive clot, or a slight movement persists in it and laminated fibrin is deposited on the wall. Pulsation in the sac ceases as soon as the ligature is tied, and usually remains permanently absent, but in some cases it returns after a longer or shorter interval and lasts for a few hours or days. This return is due to the freedom and rapidity with which the collateral circulation is established. The blood leaves the artery through the branches given off above the ligature, which dilate to accommodate the increased supply, makes its way through the minute terminal branches and capillaries into the terminals of the branches given off from the main artery below the ligature, passes through them in the retrograde direction, and thus regains the main artery to be distributed as before through its terminal branches. The greater the length of artery that has been obliterated by the ligature and disease, the greater the difficulty of the re-establishment of the circulation, and thus it is found that when two or three aneurisms are situated upon a single artery, or when, as because of secondary hæmorrhage, a second ligature has been placed upon the artery at a higher point, the probability is great that the circulation will be re-established too slowly or imperfectly to preserve the life of the tissues, and the occurrence of gangrene is to be feared.

The method of operation is to expose the artery by a suitable incision, denude it just sufficiently to allow an aneurism-needle to be passed under it, and to tie it with antiseptic catgut or silk. Both ends of the ligature are cut short, and the wound closed.

The chief dangers of the operation are secondary hæmorrhage and gangrene. Before the introduction of the antiseptic method these dangers were so great that the mortality, after ligature of the femoral, for example, was about twenty-five per cent. They are now very much less. In twenty-nine cases of ligature of the principal arteries with catgut, by New York surgeons, which I collected in 1880 (*Am. Jour. of the Med. Sciences*, January, 1881), there was no secondary hæmorrhage, and only one case of gangrene; the latter was of the foot, after ligature of the common iliac artery, and was followed by recovery. The diminution of the risk of secondary hæmorrhage is plainly due to the avoidance of suppuration about the ligature, and the freedom from gangrene appears to me to be the result of the same rapidity and ease of healing, through diminution of the interference with the vein by the inflammatory process.

The attempt has been several times made to diminish the chance of the occurrence of gangrene by repeatedly compressing the artery above the aneurism for several days before tying it, in the hope of thereby gradually enlarging the collaterals, and better fitting them for carrying on the circulation when it is finally thrown entirely upon them. The result has not borne out the expectation; on the contrary, gangrene has followed the attempt in a larger proportion of cases than when the artery has been tied without preliminary compression. A satisfactory explanation has not been found.

Other ill results of the ligature of the main artery of a limb may be permanent deterioration of its nutrition, loss of nerve and muscular power, persistent or recurrent ulceration of the skin, and suppuration of the sac.

In order to diminish the chances of the occurrence of gangrene, the limb should be wrapped in cotton immediately after the operation, and kept thus protected from losing heat until the circulation is shown to be fully re-established. If its temperature is found to remain too low, external heat should be cautiously applied in the form of hot bottles, bricks, or sand, but care must be taken that the heat thus applied is not much above the normal body heat, lest it should cause blisters.

Suppuration of the sac may occur, and either cause spontaneous rupture or make an incision necessary. The opening may be followed by dangerous hæmorrhage, or the communication between the sac and the patent portion of the artery may have previously become permanently obliterated. Sometimes pressure is sufficient to arrest the hæmorrhage and lead to a final cure by granulation; in other cases, the clots will have to be turned out and all bleeding points secured, or a second ligature may be applied *between* the first one and the sac. A second ligature *above* the first greatly exposes to gangrene.

If pulsation returns permanently in the sac and the tumor again begins to grow, several courses are open to the surgeon. If the aneurism is at the knee, groin, or elbow, flexion should first be tried, and this failing, perhaps galvano-puncture, the injection of persulphate of iron, or acupuncture; if resort to operation becomes necessary, the artery may be tied again between the first ligature and the sac, or the "old operation" of incision into the sac and ligature of all vessels entering it may be done. Both methods have proved successful.

The numerous statistics that have been collected of the various results following treatment by ligature, do not furnish a fair basis for estimating the chances after ligature with antiseptic catgut or silk, and treatment of the wound by modern methods. Mr. Holmes's statistics, in 1874,[5] gave thirteen deaths in eighty-seven cases of popliteal aneurism treated by the ligature, a mortality of nearly fifteen per cent., say one in seven; while nine cases of ligature of the femoral, three of the external iliac, and one of the primitive iliac under the antiseptic method, collected by myself in 1880,[6] gave no deaths, no secondary hæmorrhage, and only partial gangrene in one, that of the primitive iliac. There is, therefore, good reason to believe that the operation has become, under antiseptic methods of treatment, much less serious than it formerly was.

b. Metallic ligature; artery constrictor. These are methods designed with the view to avoid the risk of secondary hæmorrhage which pertained to ligature with a thread after the old method. The catgut and carbolized silk ligatures, aided by antiseptic dressings, have proved so safe in all respects that it is not probable these other substitutes will be again resorted to.

Dr. Benj. Howard proposed to place a silver ligature about the vessel tightly enough to occlude it, but not tightly enough to injure its coats, then to cut both ends short and close the wound over it. It was used successfully once by Mr. Holmes.

Dr. Speir, of Brooklyn, N. Y., devised an "artery constrictor" by which the middle and inner coats could be divided and curled inward into the vessel, the outer coat being left unbroken. It has been used successfully in several cases by the inventor and by Mr. Bryant, of London.

c. Compression of the artery, direct, indirect, and digital. Direct compression is made upon the artery by acupressure needles or wires, threads, or forceps, after incision of the skin and exposure of the vessel; indirect compression is made by suitable instruments or weights resting on the surface over the artery; digital compression is made by the fingers.

Indirect compression is an older method even than ligature of the artery, and was employed, although unsuccessfully, by Desault in the treatment of an axillary aneurism a few months before he first treated a popliteal aneurism by ligature, as mentioned above. It is claimed for Hunter, also, that he was the real originator of the treatment by compression, because he showed that complete arrest of the circulation was unnecessary, and that the compression might be partial or intermittent, and because all previous operators sought to effect a cure by obliterating the artery at the point pressed upon, a statement which does not appear to be borne out by the reports of their cases. However that may be, the former theory that a passive clot was a source of danger, and that persistent pressure upon the artery to arrest the circulation for several hours was, therefore, a more dangerous method than intermittent or incomplete arrest, which

Aneurism.

would give a laminated clot of slow formation, is now abandoned, and, as a rule, when compression is used, it is with the aid of anæsthesia or morphine, is forcible enough completely to arrest pulsation in the sac, and is continued until the contents of the sac have coagulated. Intermittent, incomplete arrest is occasionally used under exceptional circumstances. In a few cases in which pressure above the sac could not be made, complete arrest of the circulation below it, usually by the elastic bandage, has effected a cure (see Distal Ligature, farther on).

The method of cure by this means varies in the different cases; in some it is by the deposit of laminated clot, in others by a soft passive clot. The changes in the aneurismal sac are the same as those above described, and the dangers of the method are the same as after ligature, with the exception of secondary hæmorrhage. A unique consequence, reported by Mr. Pemberton,[7] was the formation of a communication several months afterward between the artery and vein at the point where pressure had been made, resulting in an arterio-venous aneurism that finally caused the patient's death.

The operative methods include the use of weights or of special instruments having the general character of a truss. The latter are numerous and varied, but all consist essentially of a branch to make counter-pressure without circular constriction of the limb, and of a pad which can be screwed or bound down upon the artery with suitable force. For weights, bags of shot are used, or pieces of lead moulded to fit the parts. They may be allowed to rest entirely upon the limb, or may be suspended by an elastic cord.

Prolonged complete arrest of the current requires the aid of anæsthesia, for the pressure soon becomes very painful; anæsthesia may be safely prolonged for many hours. It is well to aid the control of the circulation above by pressure also below, or by tightly bandaging the limb below the aneurism.

Digital pressure, which had previously been employed in two cases as an aid to compression by instruments, was first used as the sole means of cure by Dr. Jonathan Knight, of New Haven, Ct. The case was one of popliteal aneurism, and a cure was effected in about two days. The plan has since been employed in a large number of cases, and with a large measure of success. Fischer's statistics, quoted by Holmes, contain 90 cases, with 76 complete cures, and 8 deaths; six of these deaths occurred after subsequent ligature, the remaining two after amputation. In about one-third of the successful cases the cure was effected within twenty-four hours.

Digital pressure can be made only with the aid of a considerable number of assistants, and it is usual to employ them in pairs, one making pressure while the other feels for pulsation in the sac. The skin should be covered with French chalk at the point where the pressure is made, and the assistants should be carefully instructed as to the amount of pressure needed and the place where, and direction in which it should be made. When the change is made from one assistant to another, the latter should place his finger or thumb upon the artery immediately above or below that of the one whom he replaces, and this one should not remove his finger until after the artery is duly compressed by the other. Ether or morphine should be used when the patient begins to complain of the pain.

Direct compression of the artery by needles or wire or forceps, after incision of the overlying parts, is a substitute designed to arrest the current more certainly than is done by indirect pressure, and yet to avoid the risk of secondary hæmorrhage. It is to be regarded rather as a substitute for the ligature, and as such has become much less important since the introduction of the catgut ligature and the antiseptic method, although under exceptional circumstances, as with large arteries and near large branches, it may still be advisable to resort to it. The instances in which the method has been used are not numerous, and the varieties in the means employed are almost as numerous as the cases. Acupressure, after use in a very few cases, seems to have been entirely abandoned. Mr. Bickersteth[8] compressed the innominate with a leaden wire drawn loosely around it; the wire broke on the second day; a ligature was then applied, and the patient died of hæmorrhage on the sixth day. Mr. Dix[9] cured an aneurism of the carotid and another of the femoral by passing a wire under the vessel, bringing both ends out through the tissues at the side of the wound, and twisting them over a piece of cork tightly enough almost to stop the pulsation. The wire was tightened on the third day and removed on the fifth or sixth. Professor Porter[10] compressed the innominate for three days with an instrument resembling a small lithotrite; fatal hæmorrhage from the vessel at the point compressed occurred on the tenth day. Robert Perssé White[11] compressed the external iliac for one hundred and sixty-two hours with a modified form of Porter's instrument, and thereby cured an inguinal aneurism. Dr. W. Stokes, Jr., compressed the abdominal aorta with a silver wire tightened over a ring, after a plan recommended by Porter, and Mr. Holmes says the vessel was so firmly closed after pressure for a few hours that at the autopsy water could not be forced through it; the patient died of peritonitis.

Mr. McGill[12] compressed the first portion of the left subclavian with ordinary torsion forceps; after nine and a half hours the aneurism was solid and pulseless, and the instrument was removed. The patient died of pleurisy, the pleura having been opened during the operation; previous to this operation the aneurism had been much benefited by galvano-puncture.

d. Compression by Esmarch's elastic bandage. This method was first employed in 1875 by Dr. Walter Reid, of the British Navy, in a case of popliteal aneurism. The bandage was applied tightly to the leg, loosely over the tumor, and then tightly over the lower third of the thigh; then the cord was put on and the bandage removed. At the expiration of fifty minutes the pain had become so great that the cord was removed, two Carte's compressors on the upper portion of the femoral artery having been substituted. At the expiration of three hours from the commencement the aneurism was found to be pulseless; intermittent pressure was kept up for two days, and then the patient was pronounced cured. The condition of the parts found at the death of the patient a few months later, and the method by which this treatment appears to effect a cure have been described above. In January, 1881, I collected 62 cases treated by this method,[13] which may be grouped in three classes, according to differences in detail. In the first class, 52 cases, Dr. Reid's method was followed exactly or very closely; in the second class, 5 cases, the rubber tubing or the elastic bandage was used repeatedly and alternately with the tourniquet or digital pressure to arrest the circulation for several hours; in the third class, 5 cases, the bandage was used for a short time daily for many successive days, without any compression of the artery in the intervals, or with a tourniquet loosely applied. In the first class there were 28 cures, 22 failures, and 2 deaths; and of the cures 24 were obtained by a single attempt continued for about an hour on the average, the extremes of time being fifty minutes and three and a half hours, and 4 by two attempts each, separated by an interval of from one to four days. After the removal of the bandage the artery was compressed with a tourniquet or the fingers, usually for a few hours, but in one case for only one hour, and in another for five days. In two or three cases pulsation returned in the aneurism on the following day, and was then definitely arrested by compression for a few hours. In 12 of the 22 failures the same method was used in nineteen different attempts; in the remaining 10, with eighteen attempts, no pressure seems to have been made after the removal of the bandage. In at least 5 of the 12 the method was skilfully employed, with every detail used in most of the successful cases; they show, therefore, when added to the 28 cases treated successfully by this method, that it may be expected to fail in at least fifteen per cent. of the cases. As for the remaining failures, there is some reason to suppose that the method was not employed with all the care and attention to details found in the others.

A very important fact is that the method appears to involve no serious risk, and not to diminish the chances of success if resort is subsequently had to the ligature. Of the two fatal cases, in one the bandage was applied twice with an interval of three days, and retained in the last trial for nearly eight hours. The patient died twenty-seven hours afterward with symptoms of heart failure or shock, the dorsum of the foot remaining cold. In the other the aneurism (of the anterior tibial artery) had ruptured externally, and amputation was strongly urged, but refused by the patient; gangrene of the foot and lower part of the leg followed, and the patient died during the second week. The circumstances in each case were quite exceptional. Mr. Bryant applied the bandage twice for three hours each time, with an interval of four days, in a case of popliteal aneurism in a man forty-five years old. A fortnight after the second attempt he tied the femoral artery with catgut, the wound healed by immediate union, but "anæmic gangrene" followed and the leg was amputated. This is the only instance of gangrene in the 16 cases in which the ligature was resorted to after the bandage had failed to produce a cure.

The conclusion to be drawn from all these cases seems to be that we have in the elastic bandage an efficient means for safely shortening the duration of the treatment by compression of popliteal and some femoral aneurisms. The greater efficiency, the more speedy action of the method is apparently due mainly, if not entirely, to the arrest of the circulation through the collateral channels as well as through the main artery, thus securing absolute stagnation of the contents of the sac. Consequently the rubber tubing, which is drawn tightly twice or three times about the limb above the aneurism, is to be deemed the efficient part; and the principal, perhaps the sole benefit from the bandage is that of making a less severe constriction by the tubing sufficient.

The operative method is simple: thus, in popliteal aneurism, the bandage should be applied tightly to the leg, loosely over the aneurism, and tightly again above it, and the bandage or the tubing should be kept in place for one or two hours; then the artery should be compressed by a tourniquet or the fingers for several hours afterward, the compression being occasionally intermitted for a moment to see if pulsation returns in the sac. If pulsation returns within a few hours, the artery must be again compressed. The introduction of needles or a coagulating injection might be proper in connection with a second trial after a failure.

e. Compression by flexion of the limb. When an aneurism is situated at the bend of a joint, pulsation in it may sometimes be diminished or arrested by flexion of the joint, and this fact has been occasionally utilized, either as the principal means of treatment or as an adjuvant thereto.

The method appears to have been first suggested by Fleury, a French surgeon, in a paper published in the *Journal de Chirurgie*, in 1846, as an inference from his success in curing a wound of the brachial artery at the elbow by flexion. In 1852 the suggestion was put into practice by Thierry in a case of traumatic aneurism at the elbow, and in 1857 a large popliteal aneurism was cured by flexion of the knee by Maunoir, of Geneva. He tried at first to keep the leg forcibly flexed upon the thigh, but the patient could not endure the pain, so he had to be content with keeping it partly flexed by a strap crossing the shoulders, while the patient went about on crutches. This was kept up about three weeks, at the end of which time the tumor had ceased to pulsate.

Flexion has been used successfully in aneurisms of the popliteal artery, at the groin, and at the elbow. Of 49 cases of popliteal aneurism treated by flexion, analyzed by Liégeois, 26 were cured, in 11 of which flexion alone was used, in 11 others flexion in combination with other means, and in 4 flexion after other means had failed. It was used first at the groin by Dr. Gurdon Buck [14] at the New York Hospital in an aneurism which had recurred sixteen months after apparent cure by compression. Pressure on the external iliac did not arrest the pulsation, and flexion was tried as the only alternative for treatment by laying open the sac. In a case of inguinal aneurism treated by Dr. Eldridge, of Yokohama, a cure was obtained by keeping the thigh flexed upon the pelvis for twenty days.

In making use of the method it seems to be usually necessary to carry the flexion to a point at which it markedly diminishes the pulsation in the tumor, and perhaps arrests it entirely, and then to keep the limb in this position for a long time by suitable bandages or apparatus. It is well, also, in popliteal aneurism, to bandage the leg up to the knee to prevent swelling. The merits of the method lie in the facility with which it can be carried out, and in the freedom from the chance of accidents if care is taken not to make too forcible pressure.

3. Permanent arrest or obstruction of the stream on the distal side.

a. By distal ligature (Brasdor's and Wardrop's methods). Distal ligature, first suggested by Brasdor and Desault toward the end of the eighteenth century, was first performed by Deschamps in 1798; the femoral artery was tied in the middle of the thigh for the cure of a large aneurism, the upper border of which was less than a finger breadth below Poupart's ligament. As rupture of the sac threatened on the fourth day, the artery was compressed on the pubis, the sac opened, and the vessel tied above and below; the patient died eight hours afterward. The operation was next performed by Sir Astley Cooper, who tied the common femoral artery below the epigastric for a large aneurism of the external iliac; the patient recovered from the operation, but the aneurism continued to pulsate and soon afterward ruptured. In 1825 Wardrop obtained the first success, tying the common carotid on the distal side of a large aneurism in a woman fifty-seven years old. Wardrop's efforts to popularize the operation, and especially his extension of it to aneurisms of the innominate artery, have permanently associated his name with it as distinctive of that form in which the current is not completely arrested, but continues only through branches given off from the artery between the ligature and the sac; while the name of Brasdor is given to that form in which there are no such branches and the arrest of the current is complete.

The operation is practically limited to aneurisms at the root of the neck, those of the common carotid, subclavian, and innominate. In some cases in which an aneurism of the arch of the aorta has been mistaken for an innominate aneurism, and the carotid and the subclavian in its third portion have been tied, marked relief of symptoms has followed, and in two or three cases the left carotid has been tied for recognized aortic aneurism. The operation benefits by arresting or retarding the circulation in the vessel and sac and thus favoring the formation of a laminated clot. The anticipation that the pressure within the sac would be increased by the distal ligature has proved unfounded, and the first effect of the operation has often been an immediate decrease in the size of the aneurism and in the force of its pulsation.

The proportion of successes, previous to the introduction of the antiseptic ligature, was very small, but with this introduction the operation appears to have entered upon a new career of usefulness, and of applicability to cases that have heretofore been beyond aid by surgical art. In eight cases of ligature of the carotid and subclavian for innominate aneurism in which catgut was used [15] death was caused by the operation in only one, and other successes have been since reported. It is, of course, less certain in its action than ligature on the proximal side, and its use will therefore be restricted to cases in which the proximal ligature or compression is impossible or too dangerous, in other words, to aneurisms at the root of the neck, and perhaps of the external or common iliac. It is to be judged not by comparison of its proportion of successes with that of other methods, but rather as a grave alternative in a limited class of cases that are open to few other means of treatment and lead inevitably, if left to themselves, to prompt and certain death.

b. Manipulation or malaxation of the aneurism. This method, introduced by Ferguson, in 1852, and employed

twice by him, rests upon the same principle as the distal ligature—arrest or diminution of the current by an obstacle placed upon the distal side of the sac. In this method the obstacle is a fragment of old clot mechanically displaced from the wall of the sac and lodged within the artery. This displacement of a clot is thought to be the mechanism by which many of the so-called spontaneous cures have been obtained. The conditions essential to its employment are the presence of enough laminated clot in the sac to make the detachment of a piece of sufficient size possible and practicable by external manipulation, and the impossibility of safely resorting to other methods of treatment. The latter condition limits the method to a small number of cases, mainly those situated upon the subclavian artery. It is inapplicable to those situated upon the carotid, because of the certainty that small fragments will pass into the arteries of the brain and become cerebral emboli, with consequent paralysis. This accident has been observed also in cases of aneurism of the right subclavian treated in this manner, and in one of the arch of the aorta, mentioned above, in which the projecting sac was pressed back through an opening in the sternum. Rupture of the sac, which has been feared on theoretical grounds, has not occurred in any of the reported cases.

In a case reported by Mr. Little, the result was most satisfactory, and the method deserves all the more credit from the fact that apparently no other could have been employed with any hope of success. The patient was fifty-three years of age, the aneurism was of the right subclavian, had lasted nine months, was of considerable size, and pulsated strongly; the overlying skin was inflamed. January 1, 1856, Mr. Little [16] made steady pressure with the thumbs on the sac, and succeeded in displacing some of the clot and directing it toward the distal opening. During the first two days no change was noticed; on the third the pulse, at the wrist, was weaker and the arm colder, and by the tenth day no pulsation could be felt in any of the arteries of the arm. The tumor became gradually solid and ceased to pulsate, and shrunk to the size of a small walnut. The arm remained cold and partly paralyzed for a time, but a year after the operation the cure was complete and satisfactory in every respect.

4. Rapid coagulation of the blood in the sac, with or without temporary arrest of the stream.

a. Coagulating injections. This also is a method of very limited applicability; it can be used only as an adjuvant to other methods, or in exceptional cases, as of recurrence or of pouched aneurisms. Dr. Jos. C. Hutchison, of Brooklyn, employed it unsuccessfully in a case of aneurism of the abdominal aorta. It has been considered essential to its use in the treatment of an aneurism of the common or encysted variety that the circulation through the sac should be completely commanded during the injection and for some time thereafter, but if this condition can be fulfilled, treatment by distal or proximal compression or ligature will usually be possible. In certain other varieties, as cirsoid aneurism and varicose aneurism at the elbow, it has yielded good results.

The coagulating substance has almost always been a solution of an iron salt, the subsulphate, lactate, or perchloride. The coagulating power of the latter is great, but so, too, are its escharotic qualities, and its use has commonly been followed by suppuration of the sac. A strength of 20° Beaumé seems to be as great as should be used, and the quantity is set by Holmes at eighteen or twenty drops for an aneurism of the size of three and a half ounces. Van Buren thought the preference should be given to the subsulphate, which is not at all escharotic. Dr. Hutchison made nine injections of from five to fifteen minims each, in a case of recurrent femoral aneurism, without obtaining any benefit or causing any irritation; the strength of the solution varied from one in five to one in thirty. In a case of aneurism of the innominate, for which Dr. Eliot [17] tied the carotid and subclavian arteries, ten and a half drachms of a solution of the subsulphate were injected on the seventeenth day after the operation to arrest hæmorrhage from the sac. This was followed by a discharge of bloody serum for three days, and protrusion of a dry clot, which fell out on the twenty-fourth day, leaving a large cavity, from which fatal hæmorrhage took place on the twenty-sixth day.

Hydrate of chloral has been recently recommended.

b. Introduction of solid bodies. A few attempts have been made to induce coagulation of the blood in an aneurism by permanently or temporarily introducing foreign bodies, such as wire, needles, horsehair, catgut. The method rests upon the well-known facts that, if freshly-drawn blood is whipped with a bundle of fine rods, the fibrin collects upon them, and that firm clot forms upon a foreign body introduced into an artery or vein. With one or two exceptions these attempts have been made upon aneurisms that were not open to treatment by any of the methods of ligature or compression, such as aneurisms of the aorta and subclavian. The first case of permanent introduction was that of Mr. Moore; the first of temporary introduction of needles, those of Rizzoli and Malago.

Moore's case was a large aneurism of the arch of the aorta, which had destroyed part of the bony wall of the thorax, and threatened to rupture the skin. He introduced, through a fine canula, twenty-six yards of fine iron wire, moving the point of the canula about, so as to coil the wire within the sac. Coagulation promptly followed, and pulsation ceased for a time, but inflammation set in, pulsation returned, and the patient died on the fifth day. The large pouch outside the wall of the chest contained the wire imbedded in a firm clot, which extended also into the inner pouch and the artery. The opening between the sac and the aorta was about half an inch in diameter.

Rizzoli's first case was an aneurism at the elbow; the bleeding which followed the withdrawal of the needles he inserted was so profuse that the limb was at once amputated. His second case was an ilio-femoral aneurism, and after failure of digital compression he introduced six needles in such a manner that their points, crossing, formed a sort of lattice within the sac. Two were withdrawn on the third day, the others on the fourth. The tumor had become smaller and firmer, and the pulsation was less. No further change taking place, instrumental pressure was made, and effected a cure. Malago's operations were upon popliteal aneurisms in 1850, 1852, and 1855, and all terminated fatally.

March 23, 1871, Dr. Domville introduced fourteen inches of fine iron wire into an aneurism of the aorta that projected through the sternum; the tumor became firmer but continued to increase, and on the 9th April he introduced nine needles, each two and a half inches long; fatal hæmorrhage occurred on the 23d. The needles and the wire were found imbedded in a "dark, fibrinous coagulum."

In April, 1872, Mr. Murray presented a patient to the Royal Medical and Chirurgical Society, and read an account of three other cases, all treated by this method. In the first case, aneurism of the aorta and innominate, eighteen or twenty needles were introduced and left in for twenty-four hours; then twenty-four feet of wire was inserted. The patient had no bad symptoms, but died suddenly a fortnight after the last attempt. In the second case (aneurism of the aorta) needles were inserted twice; erysipelas began at the punctures and caused death. In the third case (aneurism of aorta and innominate) twenty feet of catgut was inserted; at the autopsy it was found softened and with no coagula upon it. The fourth case, the one shown to the Society, was a saccular aneurism of the subclavian. Five or six trials of complete transfixion with twenty or thirty long needles for several hours were followed each time by consolidation, lessening of size, and relief of pain.

Horsehair has been introduced by Dr. Levis (twenty-four feet nine inches) into an aneurism of the right subclavian—death a few weeks afterward; by Bryant (thirty feet) in a rapidly growing popliteal aneurism in a patient affected with ulcerative endocarditis, "with the effect of causing almost complete consolidation of the tumor;"

and by myself in an ilio-femoral aneurism where other treatment was refused (about fifteen pieces, each six inches long), without any effect.

In January, 1879, Mr. Christopher Heath introduced three pairs of fine sewing-needles, making each pair cross, into an aneurism of the left subclavian, for which he had amputated at the shoulder-joint two months previously. The needles were withdrawn on the fifth day and the tumor became solid. The patient died a few days later of bronchitis, and the aneurism, which had been caused by fracture of the first rib five months before, was found full of dense fibrin and communicating with the artery by a very small opening.

It does not appear from the history of these cases that the interference is likely to do any great harm, or, on the other hand, that much benefit may be expected from it, and therefore it should be used, if at all, only when other means are unavailable and as a last resource in desperate cases.

c. Galvano-puncture. In this method the constant galvanic current is employed to produce rapid coagulation of the blood in the sac. The details of the operation, as employed in different cases, vary greatly. Sometimes a single pair of insulated needles, one connected with the positive, the other with the negative pole of the battery, are introduced into the sac near each other, and the current passed directly through the intervening blood from one to the other; or several needles are connected with each pole and used in the same manner; or needles are connected with one pole only, and a sponge connected with the other and placed on the skin near by. When needles are connected with one pole only, it is commonly the positive pole, but sometimes the current is repeatedly reversed during the operation, and occasionally the negative pole alone has been connected with the needles. The strength of the current as employed in the different cases has varied greatly, as has also the length of time during which the application has been made.

Like both the preceding methods of producing coagulation by direct action upon the blood in the sac, and like most of the other exceptional methods, this method recommends itself only in cases that are not amenable to less dangerous and more certain methods. Inflammation of the sac and the formation of eschars about the needles, which were feared and have sometimes occurred, can be quite surely avoided by care, but the punctures sometimes suppurate, and clotting does not always take place to a sufficient extent to cure or even to relieve. A few strikingly good results have been obtained in cases of internal aneurism, either in effecting an apparently permanent cure or in averting immediate death by rupture. It has also cured some cirsoid and arterio-venous aneurisms.[18]

The weight of experience is in favor of using several needles connected with the positive pole of a battery of high tension, and of passing the current for an hour or two.

Traumatic Aneurism, and Rupture of an Artery.—A traumatic aneurism is one whose formation is the result of a wound of the artery that has divided all its coats, or of an injury (stretching, bruising) that has divided one or more of them. The common cause is a penetrating or punctured wound; less common causes are overstretching in the neighborhood of a joint and fracture. The continuity of the artery is usually not entirely destroyed, and while some of its blood escapes into the adjoining tissues the remainder continues within it and is distributed through its branches. The effused blood is in part absorbed, and in part coagulates; and after a time a distinct sac forms about it, by condensation of the tissues, and it then differs in no essential way from the common encysted form of aneurism. Its symptoms and its subsequent course are then the same, but during the stage of formation of the sac the condition presents symptoms of dangers peculiar to itself. There is the history of the injury, absence or diminution of pulsation in distal branches, local swelling and ecchymosis, and sometimes marked lowering of the temperature of the limb. There is usually a bruit but no pulsation in the swelling at first, but after the sac has formed the expansive pulsation characteristic of an aneurism is present.

During the formative stage of the sac the injury is peculiarly amenable to treatment by direct pressure at the seat of injury; and often after the sac has formed a cure may be effected by the same means. This is the one important practical point of difference between traumatic and spontaneous aneurisms.

When the injury is associated with fracture of a bone the immediate treatment, unless the symptoms are very alarming, should be confined to securing the repair of the fracture and to limiting the extravasation of blood by suitable pressure, and the treatment of the aneurism should be postponed, if possible, until after the bone has united. The presence of the extravasated blood is not a serious obstacle to this repair, while the conversion of the fracture into a compound one by an incision made to secure the wounded artery may have very serious consequences.

Exceptionally, the extravasation may be so free as to endanger the vitality of the limb by its interference with the circulation, and under such circumstances the surgeon may be compelled to turn out the clots and secure the vessel, or even to amputate. This is much more likely to be the case in complete rupture of the artery, when none of the blood brought by the artery is carried past the injury into its distal branches, but all is poured out into the tissues, and, being bound down by the enveloping fascia, exerts a pressure which checks the venous flow and prevents the establishment of collateral circulation. This condition is characterized by great and uniform swelling, absence of pulse, and notable loss of temperature in the limb.

II. Arterio-venous Aneurism.—When an abnormal direct communication is established between the trunk of an artery and that of a neighboring vein, the condition is known as an arterio-venous aneurism. When the two vessels remain in close contact, and the blood passes directly from the artery into the vein, the variety is known as *aneurismal varix*, the prominent feature being a varicose dilatation of the vein; when, on the other hand, an aneurismal pouch is formed by condensation of the adjoining tissues, the variety is known as a *varicose aneurism*, or as an arterio-venous aneurism in the narrow sense. In the great majority of cases of varicose aneurism the aneurismal sac is intermediate between the artery and the vein, and blood passes through it on its way from the former to the latter. Broca describes a subvariety in which the artery and vein communicate directly with each other, and there is an aneurismal pouch lying on the opposite side of the artery. Probably the distinction could not be made during life. In some of the classifications any case that presents a distinct aneurismal tumor, whether enclosed by a sac of new formation or formed by circumscribed dilatation of the vein, is called a varicose aneurism; but the latter variety, that in which the aneurism is formed by dilatation of the vein, seems to be much more closely allied in every way to aneurismal varix.

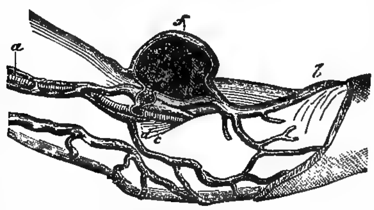

Fig. 170.—Arterio-venous Aneurism. (Bell.)

The common cause of this affection is a wound involving both the artery and the vein; but in some cases the communication forms by ulceration of the wall of the vein where it is pressed upon by an aneurism, and in one case (reported by Pemberton in "Med. Chirurg. Trans.," vol. xliv., p. 189) an arterio-venous aneurism formed at the groin ten months after prolonged instrumental pressure had been made at that point to cure a popliteal aneurism. The most frequent cause, by far, in the past, has been the wounding of the artery in venesection at the elbow. The cause in recent times is a gunshot or stab wound. Another occasional cause is fracture of the base of the

skull, by which the carotid artery is torn in the cavernous sinus. Spontaneous formation by rupture of an aneurism into a vein is rare, and almost confined to thoracic and abdominal aneurisms.

The pathological changes which are found in this class of aneurisms vary greatly in their details, according to the character and extent of the primary injury and of the communication between the vessels, and to the distance of the vessels from the heart. The principal factor in the production of these changes is the extent to which the intra-arterial pressure is transferred to and exerted upon the wall of the vein and the aneurismal sac; and this is determined by the size of the opening in the artery and the resistance offered to the return of the blood through the vein to the heart. Hence, when the communication is between an artery and a large venous trunk, such as the internal jugular, which can readily carry away the excess of blood almost as rapidly as it is supplied, the distending force is not much exerted and the obstructive changes in the vein are slight; but when the communication is between an artery and a vein in one of the extremities, or in the head, an immense aneurismal pouch may be formed or the veins may become greatly dilated and varicose. The pouch usually has a smooth internal surface and contains little or no stratified clot, and when it is formed in great part by dilatation of the vein, the orifices of other veins opening into it are seen at various points, and these veins are enlarged and their walls thickened.

The artery below the point of communication is smaller than normal, and if it has been entirely divided by the original injury, the lower portion may be occluded at the point of division; the end of the upper portion is kept open by the stream of blood.

The symptoms vary somewhat with the pathological changes; there may be a well-defined pulsating tumor, presenting the usual features of an aneurism and the special ones peculiar to this variety, or there may be simply a diffused swelling of the region, or the superficial adjoining veins may be markedly varicose. The special features are the bruit and the thrill. The bruit is continuous, with a systolic reinforcement; it is most intense immediately over the point of communication between the vessels, and becomes less, or may be changed into an intermittent murmur as the distance from this point increases. This apparent intermittence is due simply to the fact that the portion of the murmur which corresponds in time to the contraction of the heart is louder than the rest, and is heard at a distance at which the latter has become inaudible. In some cases the murmur could be heard at a great distance along the vessels; thus, in one quoted by Follin, it could be heard from the elbow to the heart; in another (of the femoral), from the head to the feet. The *thrill* is a peculiar sensation given to the hand when laid upon the aneurism, a vibration that has been compared to the purring of a cat.

The interference with the circulation below the point of communication is commonly well marked, and is shown by swelling of the limb which is not œdema, but which, in some cases at least, is an actual hypertrophy, and is accompanied by a permanent elevation of the temperature of the limb, a greater growth of hair upon it, and in one case by an increase of an inch in length. There is a feeling of numbness or of actual pain in the limb, increased by its use, and there may be a marked loss of muscular power, and sometimes persistent ulcers or eczema.

The lesion may fail to become apparent until some time after the receipt of the injury (four years in one case), and commonly it remains stationary after having reached a certain development. Those situated upon the great vessels, the carotid and internal jugular for example, seldom cause any inconvenience to the patient. In a few cases the opening into the vein has closed spontaneously, and the aneurism has been thus transformed into a simple arterial one.

Treatment.—In recent cases carefully graduated, direct pressure has sometimes availed to close the opening, and this may be aided by compression of the artery above. Operative interference in the past, which has included a variety of methods, has proved exceptionally dangerous, but the statistics for obvious reasons have lost much of their value with the improvement in operative methods and in the treatment of wounds. The operations may be divided into two main classes, according as the sac is or is not opened, and in the latter class they will further vary according to the number of the ligatures applied.

The question of interference will be determined by the extent of the disability and the vessels involved in the lesion. In the forearm or on the scalp it is usually practicable to tie all the vessels, arterial and venous, that are involved, and thus effect a radical cure. In the neck (carotid and jugular) the history of recorded cases [19] shows that the lesion rarely causes more than a moderate amount of inconvenience, that can be easily borne by the patient.

Ligature of the artery alone on the proximal side in arterio-venous aneurism of the lower extremity has proved remarkably fatal by gangrene. In 12 cases collected by Van Buren,[20] the external iliac was tied in 5, and the common femoral in 2, and gangrene followed in all; the femoral in 5, and gangrene occurred in 2. This extraordinary frequency can be attributed only to the changes produced in the conditions of the venous circulation by the disease, and I cannot believe that it would be diminished by other operative methods that should involve greater interference with the vessels, such as the addition to the proximal ligature of the artery of ligature of the veins and of the distal portion of the artery, with or without opening of the sac. The primary cause of all the changes is the pressure exerted by the escaped arterial blood, and the only plan of operation that holds out a prospect of cure, is one that will abolish that pressure, or at least reduce it to a point that is not in excess of the ability of the veins to support it. It does not seem to me necessary entirely to cut off all entrance of arterial blood into the veins; the latter, as is shown by the cases of communication between the carotid and internal jugular, can accommodate themselves to the admission of a certain amount, and it is therefore only necessary to reduce the supply to this amount. Ligature of all the veins, as well as of the artery, suppresses, it is true, all subsequent growth of the sac or continuance of the disease, but it adds a factor that is most important in the production of gangrene—obstruction of the venous flow. Moreover, the operative difficulties are extreme. The record of cases in which the sac has been opened and the attempt made to arrest all bleeding from it, is such as to discourage any one from undertaking it; again and again operators have had to resort to ligatures *en masse*, passed by means of curved needles, and more or less blindly, in deep, inaccessible corners of the wound, to the actual cautery, and even to styptics and pressure. The incision has always been very long, and the tissues have been bruised and lacerated by the prolonged search and dissection. In the only case I have witnessed, an aneurism of the upper part of the calf, the incision was more than a foot in length, the operation lasted about two hours, and at the last resort was had to persulphate of iron and graduated compresses packed deep in the wound. The wound could not be kept aseptic, and the patient died on the third day of acute septicæmia. The method seems to violate all the principles that govern modern methods of making and treating wounds, and it does so, in my opinion, in the effort to attain an end that is not only unnecessary, but introduces an element of great additional danger. If the proximal ligature alone is too dangerous to be employed, the more extensive operations are still more so. Whether or not the proximal ligature is too dangerous, under the modern improvements, is yet to be determined, but I am convinced that it is the only one which the surgeon should employ. In 1882, Professor Verneuil[21] treated an arterio-venous aneurism of the popliteal space by ligature of the artery and vein on the proximal side. After the ligature had been applied and the tourniquet removed, the tumor filled slowly with blood, and the surgeon then opened the sac and sought to secure all the vessels that opened into it. The patient recovered,

but in the remarks which the distinguished surgeon made upon the case (loc. cit., p. 276), he expresses his regret that he had opened the sac. He does not explain why he tied the vein as well as the artery; doubtless he had a good reason for it, but, in ignorance of that reason, it seems a mistake to oppose the escape of blood from the sac toward the heart. Probably he sought to effect a cure, as in other aneurisms, by coagulation and obliteration, and deemed it inadvisable to allow the venous stream to pass through the dilated and varicose veins. The case is quoted to show, what others have also shown, that a cure is possible, without gangrene, even under operative conditions that favor the occurrence of that complication, and that a like favorable result may be expected, in a proportion yet to be determined, from the less difficult and dangerous operation of proximal ligature of the artery. In an arterio-venous aneurism of the leg, ham, or perhaps even the lower portion of the thigh, which could not be made tolerable by elastic support, I think it would be justifiable to tie the artery on the proximal side, and as near as possible to the point of communication; and then, if this should not overcome the disability, or reduce it to a bearable degree, obliteration of the dilated vein by galvano-puncture or the injection of coagulating solutions might be resorted to, with temporary compression or even ligature of the vein on the proximal side, to prevent the detachment of an embolus.

A few successes have been obtained by galvano-puncture and the injection of coagulating solutions without ligature of any vessel.

III. Cirsoid Aneurism (arterial varix; aneurism by anastomosis).—This name has been given to an affection of the arteries, sometimes involving also the capillaries and even the derived veins, which differs materially from that which constitutes the common variety of aneurism, and is characterized by a uniform or irregular dilatation and tortuous lengthening of an artery and its branches. The affection is most common in the superficial arteries of the head—the temporal, occipital, and auricular—but it is also found in the hand, forearm, leg, and even involving the external iliac artery.

The change consists in a dilatation and lengthening of the artery, with atrophy of its middle coat and consequent thinning of the wall, or possibly hypertrophy by increase of the connective tissue; the dilatation may make the calibre of the vessel ten times larger than normal, and may be uniform, but is usually accompanied by the formation of small pouches. In consequence of the lengthening the artery assumes a tortuous form. The change has a marked tendency to spread in both directions, involving the arterial branches and even the consecutive capillaries and veins, and in the latter case it is known as *aneurism by anastomosis* or *racemose aneurism*. There is also reason to think that in some cases the change has originated in a nævus and spread backward to the arteries. At the central portion of the tumor, where the tortuous and dilated vessels are most numerous and closely packed, there may exist, as Lefort[22] has pointed out, a sort of central lake, as in cavernous angioma, or a real aneurism, or even an arterio-venous aneurism. The overlying skin and soft parts may be thinned, or thickened and indurated, and underlying bone may be absorbed in consequence of the pressure.

The principal causes are found in contusions and pre-existing erectile tumors or birth-marks, and the change takes place most frequently at the time, or shortly after, the age of puberty is reached. In what manner or through what agency these causes act is not known, nor why the region of the head is the common seat.

The symptoms of the disease are a soft, ill-defined swelling under the skin, in which numerous pulsating vessels can be felt, and into which tortuous arteries can be seen to pass. The overlying skin is reddened or livid, either by implication of its own minute vessels or by transmission of the color of the blood below it; the tumor communicates a sort of thrill to the hand, and a continuous murmur to the ear. In a complete typical case four distinct varieties of changes or lesions can be recognized: First, a cutaneous erectile tumor, formed by dilatation of the arterial capillaries of the skin; second, a subcutaneous arterial cirsoid tumor, formed by the dilatation of the finest arterioles under and around the first; third, dilatation and tortuosity of the main arteries leading to the tumor; fourth, dilatation of the veins coming from the tumor, sometimes with pulsations synchronous with those of the heart.

The affection is a serious one, because of its tendency to increase and the danger of hæmorrhage through ulceration of the skin or an accidental injury.

Treatment has generally proved not only difficult, bloody, and dangerous, but also unsatisfactory as regards the cure of the disease. It comprises ligature of the main trunks from which the affected arteries arise, as of the temporal, or the external or common carotid in cirsoid aneurism of the scalp, excision or incision of the tumor, caustics, galvano-puncture, and coagulating injections. Lefort (loc. cit.), who made a careful study of eighty-three cases, says that whenever treatment has been directed only to the afferent arteries, it has failed or has produced only an incomplete cure; but that, on the other hand, the obliteration of the vessels forming the central portion of the mass has been followed by the return of the afferent vessels to their normal condition. He claims, therefore, that the treatment should always be directed to this central portion. It includes three methods: removal or destruction of the mass by caustics or the knife; the injection of coagulating liquids; galvano-puncture. Removal by the knife exposes to severe hæmorrhage, but, if practised with caution, is practicable and to be recommended when the central mass predominates. Destruction by caustics (chloride of zinc) seems to be without much danger of hæmorrhage, but is slow and tedious and may cause superficial necrosis of underlying bone. Lefort recommends the injection of a solution of the perchloride of iron, which has given nine successes in ten cases; he prefers a five per cent. solution to the stronger ones. Dr. John Duncan[23] refers to four cases treated by electrolysis, three of them successfully. The variety known as aneurism by anastomosis, in which the capillaries and veins are also involved, is less amenable than the others to this method of treatment.

IV. Dissecting Aneurism.—This is a lesion occasionally found in the aorta, which has only a pathological interest, since it cannot be recognized with certainty during life and is not open to treatment. It consists of a partial rupture of the wall of the vessel, and the passage of the blood between its coats, usually in the substance of the middle coat, to a second opening into the lumen of the vessel at a lower point, or backward to one into the pericardial sac. The primary opening is usually in the arch of the aorta; the second one may be in the same vessel, or at a considerable distance in one of its branches, once in the subclavian, once even in the popliteal. When the flow is backward into the pericardium death promptly follows; in other cases the period of survival is usually short, but may be prolonged for years, and under such circumstances the track followed by the blood develops a resisting wall lined with epithelium. *Lewis A. Stimson.*

[1] E. Home, in Trans. of Soc. for Improvement of Med. and Surg. Knowledge, p. 144, London, 1873.
[2] The Successful Treatment of Aneurism by Consolidation of the Contents of the Sac. By Joliffe Tufnell, F.R.C.S.I., etc., second edition, London, 1875. [3] Practitioner, London, 1879, vol. xxiii., p. 31.
[4] Van Buren: The Treatment of Aneurism, Transactions of International Medical Congress. Philadelphia, 1876.
[5] Lancet, December 19, 1874. [6] Am. Jour. Med. Sci., January, 1881.
[7] Med.-Chirurg. Trans., vol. xliv., p. 189.
[8] Holmes: Lancet, November, 16, 1872.
[9] British Med. Journal, October 30, 1875.
[10] Holmes: Lancet, November 16, 1872.
[11] Dublin Med. Press, November 24, 1875.
[12] Med.-Chir. Trans., vol. lviii., 1875, p. 337.
[13] American Journal of the Medical Sciences, April, 1881.
[14] Am. Jour. Med. Sc., January, 1870.
[15] Stimson, in American Journal of the Medical Sciences, July, 1880.
[16] Medical Times and Gazette, May 23, 1857.
[17] Am. Jour. Med. Sciences, April. 1877.
[18] Duncan, in British Med. Journal, August, 1875, and June, 1876.
[19] Stimson, in Am. Jour. Med. Sci., April, 1884.
[20] N. Y. Journal of Med., 1848, vol. ii., p. 168.
[21] Bull. de la Soc. de Chirurgie, p. 280. Paris, 1883.
[22] Dict. Encyclopédique des Sc. Méd., art. Cirsoides.
[23] British Med. Journal, 1876, i., p. 715.

ANEURISM, ABDOMINAL. Etiology.—The principal *predisposing causes* of abdominal aortic aneurism are endarteritis and atheroma, which mainly originate in chronic alcoholism, rheumatism, or syphilis, and which act by impairing the strength and elasticity of the arterial walls. Atheroma is rather less frequently a precursor of abdominal than of thoracic aneurism.

The *exciting causes* consist in falls, blows upon the back or abdomen, sudden movements, and violent or prolonged muscular efforts. The disease accordingly exhibits a marked preference for middle-aged members of the laboring classes, and for the male sex, which furnishes about ninety per cent. of all the cases. The causative influence of excessive muscular exertion and of rapid changes in position depends upon the sudden increase of arterial tension resulting from augmented cardiac action, as well as upon the alternating elongation and relaxation of the aorta incident to movements of flexion and extension in the freely mobile lumbar portion of the spine. Blows and falls act as exciting causes in the same manner or by direct injury to the delicate internal and middle arterial tunics.

Morbid Anatomy.—Aneurisms of the abdominal aorta are, according to the statistics of Crisp, who analyzed 591 cases, only one-third so frequent as thoracic aortic aneurisms. They are usually located in the vicinity of the cœliac axis, often involving its orifice, but may affect any portion of the main trunk or any of its ramifications. Dr. Sibson, who tabulated 177 cases, found 131 aneurisms situated at or very near the cœliac axis. Quincke asserts that the site is more frequently *below* than above the axis. The branches most often involved are the common iliac arteries, the cœliac axis and its three divisions, the superior and inferior mesenterics, and the renal artery. Rather less than fifty per cent. of the aneurisms arise from the anterior aspect of the aorta. They are sacculated, according to Sibson, in sixty per cent. of the cases, and belong, ordinarily, to the false-sacculated, dissecting, or diffuse varieties. They often attain large dimensions, and exert injurious pressure upon adjacent viscera, notably upon the spine, the spinal cord and nerves, the solar plexus, the pancreas, the large and small intestine, the stomach, the kidney and its vessels, the vena cava, the psoas muscles, the receptaculum chyli, the thoracic duct, the branches of the aorta and the aorta itself. This pressure frequently induces absorption of the neighboring soft tissues, with erosion of the vertebræ, of the intervertebral fibro-cartilages, and of the ribs, intimate adhesions having first been formed between these structures and the aneurism.

The arterial sac undergoes atrophy and absorption, occasioned by augmented interarterial and external pressure, and finally ruptures, after a period varying from a few days to several years. The blood escapes into the peritoneal cavity, the retroperitoneal connective tissue, the intestine, the pelvis of the kidney or the urethra, the ductus communis choledochus, the sheath of the psoas magnus, the vena cava inferior, the mesentery, the mesocolon, the gastro-hepatic omentum, or the spinal canal. Even the diaphragm may be perforated, rupture then occurring into the left pleura, lung, primary bronchus, or into the pericardium. The method of perforation presents interesting differences, according as rupture takes place into the peritoneal and pleural cavities, or upon a cutaneous or mucous surface. In the former case, the rupture is effected by a sudden tearing of the distended and atrophied serous structure, while, in the latter, gangrene of the cutis or of the mucous membrane is produced by protracted tension and compression. In the former case the hæmorrhage is, almost unavoidably, sudden and profuse. In the latter, the aperture may be of small dimensions and partly occluded by thrombi. The fatal issue may thus be postponed, even for weeks, by the gradual formation of a diffuse aneurism from a slow escape of blood into the submucous or subcutaneous cellular tissue. Such diffuse aneurisms may even extend so far as beneath the iliac and pelvic fasciæ, or may penetrate between the layers of the mesentery and of the omenta.

Spontaneous cures are infrequently effected by processes described in the article on aneurisms in general.

Physical Signs.—Small aneurisms, growing from the posterior aspect of the aorta and enlarging exclusively backward, may defy detection by any method of physical exploration. So soon, however, as an aneurism growing from the anterior aortic wall has attained a moderate size, it usually presents on inspection, provided that the abdominal parieties be sufficiently relaxed and the intestines undistended, a visible impulse in the course of the abdominal aorta. If the aneurism be of large dimensions, the abdominal respiratory movements may be decreased, and those of the thorax perceptibly augmented. Jaccoud emphasizes the fact that the tumor, being immobile, is unaffected by the respiratory movements. On *palpation* an immobile, elastic tumor, pulsating, according to Sibson, in fifty-five per cent. of the cases, the impulse of which is systolic and expansile, is commonly detected in the epigastrium, to the left of the median line, but may project to the right side, or even be found in the hypochondriac, the iliac, or the lumbar region. A slight diastolic impulse may rarely be observed. The tumor is ordinarily smooth and compressible, but sometimes nodular, unyielding, and even non-expansile. In the latter case it may be assumed that the aneurismal walls are very thick, that abundant coagula and fibrous laminæ are present within the sac, or that the aperture communicating with the artery is occluded. The pulsations in the arteries of the lower extremities are feeble and somewhat retarded. Pressure applied to the artery *above* the tumor diminishes the size of the latter and arrests the impulse, but if made *below*, augments the tumor's dimensions and increases its impulse. Applied directly to the tumor, pressure may occasion its collapse, or may be prevented from producing this result by too great solidity and density of the fibrinous laminæ within the sac. A thrill or vibratory fremitus is occasionally perceptible over the tumor, but is oftener absent. On *auscultation* a murmur, blowing or musical, post-systolic, always single, according to Luton and Walshe, and not transmitted beyond the tumor, is usually perceptible anteriorly, rarely posteriorly, if the recumbent position be maintained. Quincke states that the murmur may sometimes be heard below the tumor, or in the lumbar region. The murmur is occasioned by the passage of blood into the sac. If the aperture of the latter be rough, the sound is rasping or musical, but it is soft and blowing if the opening be smooth. Over aneurisms enlarging only in a backward direction the murmur is perceived exclusively behind, beside the vertebral spines. In other cases it may be audible both anteriorly and posteriorly. Should the patient assume the erect posture, the murmur almost invariably disappears, but it may, exceptionally, persist in that position, or even be *only* audible while the patient is standing or sitting. The disappearance of the murmur in the erect posture is explained by the augmented tension of the aneurismal walls, occasioned by increased hydrostatic pressure, and by the consequent limitation of the quantity of blood finding ingress to the sac. No safe inference can be drawn, from the intensity or the quality of the murmur, regarding the size or the stage of development reached by the aneurism. Many observers agree that the second cardiac sound is sometimes heard, either in front or behind, after the usual post-systolic murmur.

On percussion flatness or dulness may be found over the tumor, but these signs are inconstant, owing to the frequent occurrence of gastric and intestinal tympanites, and to the varying rigidity of the abdominal parietes.

Rational Symptoms.—These are either local and due to pressure, or general and dependent upon asthenia. The most constant localized symptom is pain, which is very variable in character, in position, and in intensity. It presents itself in two different forms, the former constant, the latter paroxysmal. The former variety is variously defined as dull, boring, throbbing, or teasing; the latter as sharp, lancinating, and exhausting. The sites of the former are the epigastrium, the dorsal, and the lumbar regions; while the latter, originating in these

locations, radiates into the hypochondria, the inguinal regions, the hips, the testicles, down the anterior or posterior aspect of the thighs, and even upward into the thorax or the shoulders. The pains are the result of pressure exerted by the aneurism upon the spinal nerves, at their exit from the intervertebral foramina, and upon the solar plexus. There is no constant and necessary connection between erosion of the vertebræ and the occurrence of pain, since many cases are on record of pain from pressure on the nerves unattended by erosion, and, on the other hand, of extensive erosion without the slightest pain. Erosion is, however, of tolerably constant occurrence. Pains due to pressure on the nerves will, naturally, be usually produced by aneurisms growing from the posterior aspect of the aorta and those referable to interference with the semilunar ganglia by tumors developing from the anterior aortic wall. The intensity of the pain varies from a vague and scarcely perceptible sense of discomfort to the most excruciating torture. The lancinating pains usually surpass the fixed ones in point of severity, and both varieties are intensified as the disease advances. The fixed pain is constant, and is greatly aggravated by pressure over the painful spot, by sudden exertions, or even by trifling movements, by eating and drinking, and by the assumption of the supine or of the erect position. Relief is afforded by the assumption of the abdominal decubitus, by flexion of the spinal column, and rarely by pressure. The duration of the paroxysmal neuralgic pains varies from a few moments to several hours. Their accession is abrupt and their subsidence equally so. After their cessation the patient is left in a comparatively painless, but exceedingly asthenic condition. In a few recorded cases pain has been absolutely wanting.

The symptoms other than pain, resulting from pressure, are occasioned by direct interference with the functions of organs adjacent to the aneurismal tumors. Nausea, emesis, cardialgia, pyrosis, dysphagia, anorexia, tympanites, eructations, gastralgia and enteralgia, constipation, obstipation, and diarrhœa may be incident to pressure upon the stomach, œsophagus, intestine, or pancreas, and are, probably, in part due to interference with the sympathetic and pneumogastric nerves.

Digestive disturbances are less pronounced in connection with aneurisms growing from the posterior aortic wall. Pressure upon the liver, the hepatic duct, or the ductus communis choledochus may lead to icterus. Dyspnœa is incident to upward displacement of the diaphragm and to consequent infringement upon the interthoracic space. Irregular cardiac action attends displacement of the heart or involvement of the pericardium. Cough may be excited by irritation and inflammation of the pleura and of the pulmonary parenchyma. Compression of the renal vessels produces functional or structural disease of the kidneys. Œdema of the lower extremities is a rare symptom, due to pressure upon the vena cava inferior, which vessel, from its position, often escapes injury. Ascites results from pressure upon, or obliteration of, the portal vein, but is an exceedingly infrequent symptom. A subnormal temperature of the lower limbs, with hyperæsthesia, formication, numbness, anæsthesia, and final paralysis, are the occasional effects of pressure upon the spinal cord and nerves. Renal and biliary colic may proceed from pressure upon the ureter and the biliary passage. Irritation of the psoas magnus excites symptoms similar to those of psoas or lumbar abscess.

The General Symptoms consist in gradual depreciation of the vital powers incident to pain, insomnia, malnutrition, and impaired innervation. Extreme emaciation is sometimes observed, and may, in the absence of other adequate causes, be referred to compression or obliteration of the receptaculum chyli or of the thoracic duct. Death from exhaustion occasionally happens, but the usual termination is by rupture and hæmorrhage. The symptoms of rupture are either those of sudden collapse or, if the hæmorrhage be of gradual occurrence, those of interabdominal or interthoracic diffused aneurism and of progressive asthenia, possibly complicated by peritonitis or attended by recurrent hæmoptysis, hæmatemesis, hæmaturia, or melæna.

Aneurisms of Branches of the Abdominal Aorta.—Owing to their rarity and to their comparatively small size, aneurisms of the abdominal branches of the aorta usually present so few symptoms as to escape observation or to elude diagnosis. The branches most frequently the seat of aneurisms are, according to Lebert, the iliacs, the cœliac axis and its divisions, the superior mesenterics, and the renals, in the order named. The symptoms and signs of these tumors are similar to those of aortic aneurisms. Aneurisms of the superior mesenterics and of the cœliac axis are, however, *mobile*, and usually occasion no retardation or diminution in the pulsation of the femoral arteries. Renal aneurism is specially liable to interfere, by pressure on the ureter and the renal vein, with the functions of the kidney, and hepatic aneurisms often lead to jaundice. Statistical data regarding the relative frequency of ascites, in cases of hepatic aneurisms, are lacking.

Differential Diagnosis. — Abdominal aneurisms must be differentiated, first, from abdominal tumors to which the aortic pulsation is communicated. Those tumors most likely to be mistaken for aneurisms are carcinoma of the stomach, pancreas, omentum, intestine, and liver, fæcal tumors, gall-stones or foreign bodies impacted in the intestine, enlarged lumbar and mesenteric glands, renal tumors, as hydro- or pyo-nephrosis, floating kidney, ovarian or uterine tumors, enlarged or displaced left lobe of the liver and encysted peritoneal exudations. Not only may these tumors receive an impulse from the aorta but they may produce a murmur by pressure upon that vessel. The character of their impulse is, however, heaving or lifting and not expansile, and it, as well as the murmur, can ordinarily be made to disappear by placing the patient upon his hands and knees, when the tumor gravitates away from the artery. The tumors in question are, as a rule, movable, aneurisms of the aorta immovable. Aneurisms of the aorta's branches may be mobile, but their murmur persists after displacement of the aneurisms from their original position, which is not true of the other tumors under consideration. The latter are, moreover, of greater consistency, and are more frequently accompanied by varicose abdominal veins, by ascites or by œdema of the legs, and, if carcinomatous or tuberculous, by a more decided cachexia.

Secondly, from lumbar and psoas abscesses, which simulate aneurisms chiefly by causing dorsal pain and spinal curvature, but which are unattended by impulse, thrill, or murmur.

Thirdly, from various neuralgic affections, as renal and biliary calculus, gastralgia, enteralgia, neuralgia of the testicle, lead colic, lumbago, muscular rheumatism, and sciatica, the exclusion of which must depend on thorough physical exploration.

Fourthly, from abnormally forcible pulsation of the aorta. This is not accompanied by pain, thrill, dulness, murmur (unless the latter be excited by pressure with the stethoscope), or expansile impulse, and is often developed in connection with dyspepsia, profuse hæmorrhage, or hysteria in young, chlorotic women. This form of pulsation is not localized but propagated through the entire aorta and its chief branches, nor is it attended by abnormal dilatation of the artery. It may be produced either by temporarily increased force of the systole, due to excitement, or by hypertrophy of the left ventricle. It is sometimes observed in aged women, with relaxed or retracted abdominal walls, and with lessened arterial pressure incident to spanæmia.

Fifthly, from pulsatile, malignant, renal, hepatic, or pancreatic tumors which, though very difficult to diagnosticate, are accompanied by more marked cachexia than aneurisms.

Sixthly, from abscesses or furuncles of the abdominal walls, the superficial and inflammatory character of which is easily demonstrated.

Prognosis.—Abdominal aneurism is an exceedingly grave disease. While cures. either spontaneous or due

to therapeutical interference, are sometimes observed, the overwhelming majority of cases terminate fatally within a period varying from a few months to several years, either by rupture, which occurs, according to Sibson, in seventy-seven per cent. of all the cases, or by progressive exhaustion. The prognosis is unfavorably affected by the coexistence of any chronic disease, particularly of emphysema, phthisis, or asthma, which accelerate the progress of the aneurism by the repeated succussion movements incident to paroxysms of coughing. In some instances, all symptoms may disappear, only to reappear after a variable interval. In other cases the disease may remain latent until shortly before its fatal termination.

Treatment.—This is either palliative or curative. The former aims at the mitigation of suffering caused by pressure or by complicating diseases, the latter at obliteration of the aneurismal sac by the deposition of laminated fibrin. The means best adapted to the palliation of pain are chloroform and aconite, hot applications, leeching and cupping, employed at the seat of the aneurism, and, most potent of all, morphine hypodermically administered. Insomnia demands chloral and opiates.

The means employed to facilitate and hasten the deposition of fibrin within the sac relate to reduction of arterial tension, and to diminution of the rapidity of the blood-current. Valsalva's method, based upon venesection and starvation, is justly abandoned. The postural and dietetic treatment of Mr. Tufnell has yielded encouraging results. As an example of these we cite two abdominal aneurisms cured by Mr. Tufnell, after treatment protracted respectively thirty-seven and twenty-one days. In accordance with this method the patient is confined to the horizontal posture from eight to thirteen weeks, according to the progress made. No movement is allowed, and the diet is restricted to eight ounces of liquid and ten ounces of solids daily, the *menu* being as follows: For breakfast and supper, two ounces of wheaten bread and butter, with two ounces of milk, tea, or cocoa; for dinner, meat three ounces, potatoes or bread three ounces, and water or claret four ounces. Laxatives are daily used. The probably insurmountable difficulty attending this method consists in the physician's inability to secure the patient's efficient co-operation in so protracted and fatiguing a treatment. Better co-operation and greater success may be expected if the treatment merely embrace the limitation of physical exertion within proper bounds, the employment of nourishing but unstimulating aliments and drinks, attention to the bowels and the use of aconite, hydrocyanic acid, or digitalis to secure regular and moderate cardiac action. Alcoholics may, however, be sparingly used in case of evident cardiac weakness. Iodide of potassium, in doses of fifteen to twenty grains, thrice daily, is strongly recommended by Doctors Balfour, A. Flint, and Boullaud. Its beneficial effect is attributable to depression of the heart's action and to consequent diminution of vascular tension. Ergot, hypodermically, is advocated by von Langenbeck on the same theoretical grounds.

Proximal or distal compression of the abdominal aorta, for the cure of abdominal aneurism, first suggested by Mr. Holmes, finds many warm advocates and boasts a number of successful results. The preliminary treatment consists in evacuation of the bowel, and in the expulsion of flatus. Anæsthesia is essential. The instrument employed is the abdominal tourniquet, and sufficient pressure is applied to completely arrest the blood-current in the aneurism. Mr. Murray recommends that the treatment be conducted as follows:

1. That pressure be applied for four hours. If *no* effect be then apparent the first attempt is abandoned. If *any* diminution of impulse be manifest, the tourniquet is applied for another hour.

2. In the event of failure, at the first operation, another trial is made, after a few days, and pressure maintained from six to eight hours.

3. If the second attempt fail, pressure may be continued, at the third operation, twelve hours, but instantly removed if inflammation or shock supervene.

Wm. H. Flint.

ANEURISM, THORACIC. In this article no attempt is made to discuss in detail the pathology of aneurism in general, as that will be found under its proper heading. It is intended rather to present in as condensed a form as possible the principal points bearing upon the diagnosis and treatment of this particular form of the disease.

Etiology and Pathology.—In seeking for the causes which are operative in the production of thoracic, as of other forms of aneurism, we must bear in mind the two main conditions which are in themselves the most powerful agents, viz., a weakened condition of the arterial walls, and increased blood-pressure. All circumstances, therefore, which tend to bring about one or other of these disordered states tend to induce the formation of an aneurism. Probably one alone will sometimes be sufficient, but if both together unite, the necessary consequences are rendered still more certain.

A change in any of the tunics of the artery which destroys its natural elasticity will diminish its resisting power and thus render it liable to become distended at the affected part. This change may be of an inflammatory or of a degenerative nature—more frequently the latter. Chronic endarteritis or atheroma is the commonest pathological factor met with in these cases. The histological changes in atheroma resulting in aneurism are observed to the greatest degree in the middle coat of the vessels, and, according to Cornil and Ranvier, in all spontaneous aneurisms the middle coat has either partially or totally disappeared. It has been suggested that atheroma commencing in the media may, in some cases, be due to an endarteritis obliterans of syphilitic origin, which would explain the frequent association of that disorder with aneurism.

The constitutional conditions which are known to predispose to atheroma and, therefore, to aneurism are hereditary predisposition, gout, rheumatism, kidney disease, syphilis, and alcoholism. To these must also be added strain and laborious occupations involving repeated (though less severe) straining efforts. It is sudden increase in the blood-pressure, however, which is much more liable to induce aneurism than prolonged exposure to a moderate degree of increased tension, as seen in Bright's disease. It has, moreover, been fully proven that tight clothing, as in soldiers, acts injuriously in intensifying the effect of any straining effort. Occupation, therefore, is a direct exciting cause of thoracic aneurism. Any kind of work which, besides being laborious, involves at times powerful muscular efforts, must be looked upon as a factor—perhaps often the most important factor—in the etiology. Soldiers, as above noted, are notoriously prone to be affected by it, being subject to a combination of injurious influences. Prostitutes, also, frequently have aneurism of the chest from being affected with syphilis and leading lives of dissipation and excitement, highly provocative of muscular disturbances.

Age.—Aneurism of the aorta may occur at any age, but it is especially common at the more advanced periods of middle life—between forty and fifty. Very few cases have been observed below twenty. The arteries of young persons are sound and will bear a sudden strain without injury. Old people very commonly have atheromatous arteries, but in them the circulation is weaker, strain is rare, and thus they seldom suffer from aneurism.

Sex.—Men are much more liable to aneurism than women. According to Dr. Peacock from two-thirds to four-fifths of the cases of circumscribed aneurism occur in males, while dissecting aneurism makes its appearance in the two sexes with equal frequency. The difference is, no doubt, to be accounted for from the fact that men are much more exposed to the efficient promoting causes, viz., strain, laborious occupations, syphilis, and intemperance.

Symptomatology.—The mere existence of a dilatation at some part of the aorta is not necessarily accompanied by manifestations of disordered function or local distress (symptoms). Except, therefore, it mechanically interferes with neighboring parts, it may continue even for a long time unsuspected. The occurrence, then, of symptoms which will indicate the existence of thoracic aneu-

rism, depends more upon the exact situation of the tumor than upon any other circumstance. The symptoms also will present wonderful variety in accordance with the varying locality and direction of the expansion of the growth. The clinical history of these patients previous to the development of the characteristic symptoms, is often extremely indefinite. It is quite common to find a man seeking advice for a loss of voice or a harsh cough, or a thoracic pain, found to be due to an aneurism of some standing, and yet he will give an account of having enjoyed excellent health in every respect until (perhaps quite recently) these symptoms attracted his attention. Again, sometimes a quick pain, with palpitation and breathlessness, has been observed at some remote period, to be followed later on by other symptoms of intra-thoracic disorder. Or, some laryngeal or bronchial symptoms may have been coming on imperceptibly for a long time past. In many cases, belonging to one of the above types, of men above middle age, whose general health and nutrition remain unimpaired, suspicion of aneurism may very reasonably be entertained.

The symptoms of thoracic aneurism, therefore, are mainly the symptoms of intra-thoracic pressure, and mostly differ in no respect from those produced by tumors of different nature in the same situation. The symptoms consist of the manifestations by which we can recognize displacement of lung-substance, compression of the main or secondary air-tubes, irritation or destruction of nerves, obliteration of venous channels, obstruction to the feeding-tube, or erosion of some of the bony structures.

The principal symptoms of intra-thoracic pressure may be thus enumerated—pain, dyspnœa, altered voice, cough, stridor, headache, and disordered vision, and lastly, paraplegia.

The *pain* of thoracic aneurism is a very frequent symptom, but very variable as to its character, degree, and situation. In not a few cases pain of some kind will be the first indication of existing disorder. Early pain is usually of a somewhat lancinating nature, and suggestive of neuralgia. It is often complained of as darting across some region of the chest or along certain nerves to distant parts. When the aneurism, for example, is seated in or near the innominate artery, the pain is often referred to the back of the neck on the right side and behind the right ear. When in the transverse arch, the pain may be across the top of the chest and down perhaps the entire length of one arm. Pains of this kind should always prompt a search for internal aneurism. Later on in the complaint the pain is likely to be of a steady, wearing kind, and referred to some fixed spot, probably deep in the chest. Aneurisms pressing backward against the vertebral column and the spinal nerves emerging therefrom have two special forms of pain connected with them. Either a persistent boring pain experienced in some particular part of the spinal column—or a definite intercostal neuralgia, having the distributive, intermittent character and tender spots often unusually well marked. There is sometimes pain of a real anginoid character, accompanied by a sense of tightness in the chest, but it is very seldom that attacks of true angina with the typical features of this complaint are witnessed. Pressure on the phrenic nerve has been found, sometimes, to be accompanied by a painful feeling of constriction round the lower part of the thorax, together with dyspnœa and singultus, from disturbed innervation of the diaphragm.

Dyspnœa is a very frequent symptom, and is of varying character and degree in accordance with the cause to which it may be due. It may arise from compression of a portion of the pulmonary structures, from pressure upon the trachea, upon a main bronchus, or upon the pneumogastric trunk or one of the recurrent nerves. An aneurism must have attained to a considerable size before it can shut off a portion of a lung sufficient to produce decided dyspnœa. Shortness of breath, therefore, will not be much complained of in the early stages, except the tumor interfere with some of the other structures just named. Compression of the trachea commonly occurs from aneurisms of the arch, and the dyspnœa will be observed to exist both in inspiration and expiration. It is accompanied by enfeeblement of the respiratory murmur in both lungs, and the laryngoscope shows the mechanism of the vocal cords to be normal. Standing beside such a patient, it is quite usual to hear a rough, raucous sound of peculiar calibre accompanying both inspiration and expiration, especially when these acts are performed somewhat forcibly. The dyspnœa here, as in the last-mentioned form, is very markedly increased by even slight exertion, the chief reason, no doubt, being that the tumor, being expansile, the increased heart's action expands it, and causes it to compress the elastic tube more firmly. In exceptional cases of tracheal compression, paroxysms of intense dyspnœa may be occasionally witnessed, and that without direct involvement of any of the important nerves. Position will often relieve the respiratory distress considerably, and patients very frequently, of their own accord, rest or sleep, leaning the chest well forward to take off the pressure from the windpipe. If a main bronchus be compressed (and it is most often the left), the dyspnœa is not likely to be so great, and enfeebled breathing is found in the corresponding lung. It has long been recognized that pressure upon the important nerves supplying the muscles of the larynx which pass through the chest will cause dyspnœa, and that, very often, of the most intense kind. Here the striking feature is dyspnœa *in paroxysms*. There may be periods of comparative calm, during which there is only a moderate shortness of breath on making some exertion, but suddenly, with or without any exciting cause, severe suffocative dyspnœa sets in, and, in some cases, actually proves fatal. This result may be brought about either by the compression or involvement of a pneumogastric nerve, or a recurrent laryngeal nerve. Sometimes nerves of both sides are implicated. Owing to its situation, the left side is more often affected than the right. When the latter is in question, it is generally from its being disturbed by the dragging of a tumor upon the root of the right subclavian artery. It is held by some that this form of dyspnœa may be brought about either by spasm of the muscles supplied by the recurrent nerve or by their paralysis. Pressure, it is said, will either irritate or destroy a nerve. Irritation will cause spasm, destruction, paralysis. There does not, however, seem to be any reliable evidence of the occurrence of spasm as a cause of dyspnœa. While, on the other hand, whenever decided laryngeal symptoms are observed from intrathoracic pressure, the laryngoscope nearly always shows the existence of paralysis in a greater or less degree. Unilateral paralysis may exist for a long time without marked dyspnœa, but, if the opposite muscles become affected, the liability to paroxysmal attacks becomes developed, the flaccid cords are sucked together by the inspiratory effort, and a suffocative condition is induced. Why does this occur in paroxysms? It may be either that a rapid temporary enlargement of the tumor occurs (from exertion, etc.), increased pressure results, and the paralysis is rendered *complete;* or it may be that, from incomplete coughing efforts, mucus collects in the glottis, and forms a complete barrier in the already partially obstructed glottic opening. A rare form of dyspnœa in aneurismal patients consists in a simulation of ordinary asthma. I have seen one such case in a young woman where the picture presented was exactly that of a common attack of spasmodic asthma.

Alterations of voice are observed only when the tumor presses upon one of the recurrent nerves, or a pneumogastric trunk. The changes in the voice consist mainly in diminution of its power and clearness in varying degree, together with hoarseness, and sometimes a squeaky or high-pitched tone. The loss of voice may come on quite suddenly, and ultimately complete aphonia may result. These laryngeal symptoms may be among the very first complained of, thus simulating catarrhal laryngitis, for which this condition has frequently been mistaken. Laryngoscopic examination almost invariably shows deficient abduction of a vocal cord (more frequently the left). If the paralysis be incomplete, the affected end is

seen, on phonation, to fail to reach the median line, and thus an open space is left between the two. If it be complete, the paralyzed band remains almost, if not quite, stationary, and the healthy cord is seen to move rapidly across the median line until it approaches its fellow of the opposite side.

Stridor is specially noticed when an aneurismal tumor presses upon the trachea or one of the main bronchi. It differs altogether from the stridulous respiratory sounds heard in cases of laryngeal disease, and is distinguished also from them in that the ordinary speaking voice remains unimpaired. The stridor is usually a rough, low-pitched, growling sound, accompanying both inspiration and expiration, and giving the impression of originating deep within the chest. It is markedly increased by full breathing. This is the so-called "stridor from below" of the older authors.

Cough very commonly occurs during the course of a thoracic aneurism. It is produced mainly by the irritation from pressure of the pulmonary and laryngeal nerves, and is often very frequent and distressing. If there be laryngeal paralysis it will probably be husky, and even suppressed. When tracheal pressure with stridor exists, the cough likewise becomes loud, rough, and clanging in character. The expectoration at first is very small in quantity—in fact may be so throughout; but when there has been much pulmonary irritation, or when a tracheo-bronchial catarrh has been set up, large quantities of purulent expectoration may be got rid of. Blood sometimes appears in the sputum, and must always be looked upon as a sign of impending danger.

Dysphagia is a symptom more often seen in connection with other forms of intra-thoracic tumor than with aneurism. It has also been clearly proven that an aneurism may have exerted considerable pressure upon the œsophagus and yet no resulting dysphagia have been observed. Certain peculiarities in œsophageal obstruction from aneurism (as compared with that from other tumors or from organic stricture) are these: that it is variable, perhaps at one time of day nothing can be swallowed, and again, later on, fluids or semi-solids pass with comparative ease; and, secondly it is altered by position, the patient may be able, by removing the weight of the tumor on leaning well forward, to swallow fairly well, while the same thing is impossible in the recumbent position.

Engorgement of the vena cava and its branches, from pressure of the sac upon this great trunk or upon one of the innominate veins, occurs pretty frequently. It is indicated in the lesser degrees by undue fulness of certain of the superficial veins of the neck, shoulder, and front of the chest. In an extreme degree the appearances produced are very striking. The face is purple and congested, the eyes are suffused, the superficial veins greatly distended with blood and mostly tortuous. (See Fig. 1.) The tissues at the root of the neck become infiltrated and present a soft, swollen appearance, obliterating more or less the hollow above the clavicle. The congestion of the internal veins, which must simultaneously occur, causes these patients to suffer from headache and often great drowsiness, and death may take place in a comatose condition. Pressure on the brachial veins will cause swelling of the corresponding arm.

Difference in the Size of the Pupils.—The anterior roots of the spinal nerves from the sixth cervical to the sixth dorsal (according to Brown-Séquard to the ninth or tenth dorsal) supply filaments to the cervical sympathetic which pass to the iris. When an aneurism presses upon these nerves, then ocular symptoms are observed, according to the degree of the pressure. If slight, then irritation only is produced, and, as a consequence, dilatation of the corresponding pupil. If considerable, then paralysis is produced, and we find permanent contraction of that pupil. With reference to this symptom, it must be developed to a decided degree before any reliance can be placed upon it, because the slighter differences in size between the two pupils are quite commonly observed in healthy persons. Even when clearly made out its importance is not great from a diagnostic point of view, for there are generally then present many more reliable indications of the disease. But it can be used as one means to assist in enabling us to locate more precisely the seat of the tumor.

Emaciation is very frequently wanting, and persons with large tumors may remain quite well nourished. Considerable emaciation is, however, often seen arising from coincident weakness of the digestion, want of exercise, and continued suffering. Marked wasting of the tissues has, in rare cases, been traced to pressure upon the thoracic duct, and again, less rapidly, from pressure upon the œsophagus and inanition.

Such are the chief symptoms of thoracic aneurism, which are the result of the intrathoracic pressure it must sooner or later produce, and it is to them we must generally look to establish a diagnosis. But there are others which must be mentioned. It sometimes happens that the objective signs of aneurism may be present while subjective symptoms are entirely wanting. But the contrary is more generally true. Various complaints will be made before the existence of their cause can be satisfactorily made out. Much, of course, will depend upon the situation of the tumor. Patients often first experience pains in the chest, the different characters of which have been already alluded to. As the tumor increases in size, these painful sensations may be modified in various ways by the occurrence of complicating inflammations of surrounding parts, and especially the pleura. There may be also a distinct sensation of throbbing or pulsation in the chest in the region of the aneurism. Palpitation of the heart and tightness in the chest are often associated with these. It may also be observed by themselves that alterations of position have an effect in increasing or diminishing their discomfort. Then dyspnœa of some kind is likely to occur and to be followed by dysphagia, neuralgias, pareses, or actual paralysis (perhaps only formication or numbness), some anæmia, diminution of strength, and sometimes œdema. An aneurism of the chest may thus cause death by a gradual process. But much more commonly we observe continuous increase in the tumor until it finally ruptures and death ensues, either directly from hæmorrhage or indirectly from the effects of the effusion of blood upon some vital organ. Rupture is generally associated with enormous hæmorrhage, which is inevitably fatal in a few minutes or seconds. It does happen, however, that smaller bleedings occasionally make their appearance for some time (it may be a day or even more) previous to the final gush. In the case of a gentleman, under the care of the writer, who died of this disease a short time ago, small quantities (a few ounces) of bright arterial blood were brought up for more than twenty-four hours preceding the actually sudden end. In this case the aneurism broke into the substance of the lung, and evidently had leaked into a small bronchus during the time mentioned. The final rupture took place into the left main bronchus, and was accompanied by a great spirt of fluid blood, and followed by instant death. Hæmoptyses sometimes occur at long intervals (years) in aneurisms, generally from associated pulmonary congestions.

When rupture takes place, it may be accompanied by a sense of tearing within the chest, and if the blood do not appear externally with cough or efforts of vomiting (through the trachea or through the œsophagus), then it will be recognized by the accompanying pallor and syncope with failure or extinction of the pulse. Escape into a pleural cavity is common, and is marked by severe pain and dyspnœa, and by the presence of the physical signs of effused fluid. I have seen one case of rupture into the pulmonary artery when the symptoms consisted in sudden pain, collapse, want of pulse, and tumultuous action of the heart for about two hours before death. External rupture is comparatively rare. If impending, this fact is recognized by the commencing lividity and finally gangrenous appearance of the tensest portion of the projecting tumor. This accident is sometimes induced by straining or falling, or by rough handling.

Physical Signs.—The foregoing symptoms (which are mainly those of excentric pressure) are indicative of intra-thoracic tumor of some kind, but cannot indicate aneu-

rism specially. On observing any combination of them, we must turn to the physical signs to determine the character of the tumor—they are, of the two, therefore, the more important; and both together will, in the majority of cases, enable a positive diagnosis to be arrived at. These physical signs are derived both directly from the tumor itself and indirectly from an examination of the neighboring organs which may have been pressed upon, displaced, or otherwise interfered with by the encroaching tumor. The signs, as regards the aneurism, will evidently depend mainly upon its size and its exact position, especially as regards the surface of the chest.

Inspection will readily demonstrate the existence of any distinct bulging from the parietes of the chest. This may be only a slight or ill-defined elevation of a circumscribed area, or it may be a tumor of some magnitude. The elevated part, moreover, is seen to pulsate (almost) synchronously with the apex of the heart. The situation of the pulsating prominence depends upon the portion of the aorta involved, and the direction in which it has been tending. Aneurisms of the ascending arch are most commonly seen in the second or third interspace of the right side. Those of the descending aorta will most commonly reach the surface on the posterior or lateral wall of the chest. The skin over the prominence is usually healthy, except when the external tumor is large, when it may be red or livid. There may be no elevation from the general surface, the eye only detecting a pulsating spot similar to that over the cardiac apex. In the absence of these more characteristic appearances, if the front of the chest be carefully examined while the patient stands sideways to the observer, a more or less distinct systolic heaving of the chest-wall can be noticed, especially when the respiration is withheld. This indicates usually an aneurism of considerable size and deeply seated. If the heart be displaced, this fact can also be determined by the altered position of the apex-beat.

Palpation of the chest is of service only when the tumor sufficiently approaches the chest-walls. Local fulness or bulging can be appreciated, pulsation can be located, and the force of the impulse measured. Frémissement, or thrill, systolic in rhythm, can also not unfrequently be felt, perhaps over the entire area covering the tumor; and following this, sometimes a diastolic shock. In obscure cases, where a deep-seated aneurism may be suspected, the bimanual method of examination may prove of great service. The patient's chest is firmly grasped between the two extended hands laid flat upon the surface. By this means a diffused sense of expansion will be experienced which is extremely significant and can only be ascertained in this way. The suprasternal notch should also be explored. The patient's head being bent forward to relax the sterno-mastoid muscles, one or two fingers are pressed deeply into the fossa and beneath the manubrium sterni, when pulsation or thrill communicated from the transverse portion of the arch can be distinctly perceived. Another physical sign of very great diagnostic importance, and which is also to be obtained by the educated sense of touch, is what is now known under the term "tracheal tugging." It is but quite lately that attention has been directed to this method of examination, and it is only now that its value is being realized. To examine for this sign proceed as follows: Let the patient be seated upright and with the head well thrown back, in order to put the windpipe upon the stretch. Then, with the finger and thumb of the right hand grasp the cricoid cartilage or the lower border of the thyroid, and make steady pressure upward. If a deep-seated aneurism be present which impinges at all upon the trachea or one of its principal divisions, then a very distinct and unmistakable *tugging downward* will be felt with each systole of the heart. When the heart is acting strongly, or when aortic incompetence is present, considerable rhythmical pulsation may be communicated to the fingers from the adjacent carotids, but with a little care this cannot be mistaken for the tugging directly downward above described. I have observed a considerable number of cases of thoracic aneurism, cardiac and other thoracic diseases with reference to this sign, and I have never observed it produced by any other condition but aneurism. In one case, which I saw in consultation, there seemed clear evidence of an aneurism of the transverse arch, and the presence of stridor and paroxysmal dyspnœa showed its interference with the trachea and nerves. No tugging could be felt. The autopsy, however, showed that the tumor was completely filled with firm laminated fibrine, and its pulsatile character was lost. Except in cases of this kind (which must be of pretty long standing) tracheal tugging may always be looked for in central aneurisms of the chest.

Percussion elicits a flat note over the area of the aneurism which is in contact with the chest-wall. This area, of course, may give no idea of its actual size, for its principal bulk may be buried beneath healthy lung-tissue. A modified dulness may sometimes be found for some distance round the flat region. It is often impossible to separate the dulness of the aneurism from that over solid organs, the heart, liver, etc. Of course, if the tumor be entirely deep-seated, the percussion may be everywhere normal. If also the lungs be emphysematous, no information can be obtained from percussion.

Auscultation over an aneurism of the aorta reveals of necessity only a systolic and a diastolic sound, such as we hear over the vessel itself. The systolic, however, may be modified, and is sometimes accompanied by murmur. The modification consists generally in loudness, while, at the same time, a sense of impulse is conveyed, the so-called *bruit de choc*. The diastolic sound is communicated from the aortic valves, any increase in their tension intensifying the second sound over the aneurism. It is always accentuated when the diastolic shock is perceptible on palpation. Systolic murmurs are of tolerably frequent occurrence. They are probably produced in one of two ways: either by sudden alteration in the calibre of the vessel (causing fluid waves or eddies), or by the vibrations produced by contained coagula or irregularities in the course of the blood-current.

The systolic murmur of aneurism is generally blowing in character, but sometimes possesses a decided musical or "cooing" quality. Its seat of maximum intensity is likely to be the central part of the tumor, and it is not generally diffused to any very considerable distance from this. The significance of the murmur is derived from its seat of maximum intensity being away from that usually associated with valvular lesions, and from its being accompanied by a magnified second sound. Heard alone (*i.e.*, without accentuation of the second sound) a systolic murmur is rather indicative of some other condition than aneurism. Indeed diastolic accentuation, if confined to some circumscribed dull area in the neighborhood of the aorta, is of more value than any murmur. Any murmurs generated at the aortic valves and orifice are likely to be transmitted through an aneurismal tumor as well. Often, therefore, double aortic murmurs are to be heard in this situation. Sometimes, however, similar to and fro sounds are generated within the sac itself, their origin being declared by their being much louder over the corresponding area than elsewhere, by being much more restricted to this region, and by not being at all necessarily associated with dilated hypertrophy of the left ventricle. A diastolic murmur alone may, exceptionally, be heard arising from an aneurism. Over the tumor the respiratory murmur is absent, but on passing just beyond the edges of this, the breath-sounds are heard, but generally of a somewhat bronchial character. In the same areas the voice will have a bronchial resonance, although decided bronchophony will not be found (or, at any rate, is rare).

The *pulse* in internal aneurism may, or may not, afford positive information. The arteries themselves are frequently in a diseased condition, fibroid or sclerotic, and may thus affect the pulse. The state of the heart will also have to be taken into account. If, however, the blood be flowing into an aneurism of considerable size, special alterations in the blood-current in the parts on the distal side of this, may be observed and delineated. The effect of the diverticulum is to act like the empty rubber ball in the ordinary syringe, *i.e.*, to make the current

more even and steady and less spasmodic and jerky. When, therefore, a sphygmographic tracing is taken, the curve is found to differ from the normal one in accordance with this mechanism. The ascent of the systole is less abrupt, more gradual, and the descent also occurs without the same sharpness. The necessary result of this is to render the apex of the curve more rounded, less acute than the natural pulse. The larger the sac and the more distensible the walls, the better this kind of tracing is brought out, while fibrillation of the contents, and stiffening of the walls tend to obscure these peculiarities and cause the tracing to resemble the normal curve. The value of these observations is greatest when we examine at the same time the corresponding artery of the opposite side, or else the same artery (or a branch of it) above the region of the suspected aneurism. It is not uncommon to find such a degree of difference between the pulses of the two sides as may be clearly recognized by the finger. The differences consist in delay of the pulse and in alteration in its volume. Delay of the pulse in the radial artery is a diagnostic sign upon which too much stress must not be laid, and, indeed, it is very often absent. Diminution in the calibre of the radial pulse of one side is important as an additional point of evidence in a case of suspected thoracic aneurism. Its positive value is, however, detracted from by a consideration of the fact that the same thing is often seen from congenital peculiarity or from irregular distribution of the blood-vessels of that arm. The latter possibility should always be sought for, and a comparison made between the brachials of the two arms. The alteration in the volume of the pulse may be produced by twisting or distortion of the vessel, by dragging upon it by the advancing growth, or by partial or complete obliteration of the lumen by the entrance into it of detached fragments of fibrine. The only special distinguishing mark of embolism is the suddenness with which it is apt to occur.

Thoracic aneurism is very frequently associated with changes in the heart and in the circulation. Other neighboring organs also become physically altered by reason of the pressure, or other interference, to which they may have been subjected. These conditions can generally be recognized by physical examination. Under some conditions, an aneurism may be the direct cause of hypertrophy, but the heart may remain entirely unaffected, even in the case of large aneurisms of long-standing, provided there be a sound condition of the aortic valves. As, however, atheroma is often the common cause of both aneurism and aortic valvular disease, the former is frequently found along with dilatation and hypertrophy of the left ventricle. This backward affection of the ventricle cannot, therefore, be used as an argument in favor of aneurism, nor can its absence be construed against it. Displacement of the heart is often seen. This is generally a downward displacement only, or with some inclination to the left. When the tumor affects the descending aorta, the heart is displaced forward. If incompetence of the aortic valves be present, as often occurs, its existence is recognized by the usual physical signs. The cause of the incompetence may be either atheroma, as above mentioned, or the altered calibre of the root of the aorta produced by the tumor, *i.e.*, relative incompetence with healthy valves near to which the expansion has begun. Tumors near the origin of the aorta are also liable to cause pericarditis. This occurrence has frequently been found post-mortem, and is occasionally witnessed during life. Dr. Byrom Bramwell ("Diseases of the Heart and Thoracic Aorta," p. 714) says: "In any case of non-rheumatic pericarditis occurring after the age of forty, in which the cause of the pericarditis is obscure, I strongly suspect the presence of an aneurism." The same author suggests that aneurism in the same locality may account for certain cases where pericarditis and angina pectoris have been observed at the same time. Pleurisy is a common complication, and must be looked for either from friction-sounds or from the signs of liquid effusion. It occurs most often with aneurisms of the descending aorta. The existence of a pleurisy in the base of one lung, followed by prolonged pain in the same region, otherwise unaccounted for, will certainly sometimes lead us aright by suggesting aneurism.

If a main bronchus be compressed, the corresponding lung becomes comparatively airless, its circulation is impaired, and catarrhal conditions prevail. In consequence of this the following physical signs will be found, viz.: Moderate dulness on percussion and enfeebled respiration, with or without moist râles. In a few of these cases a whistling sound can be made out over the situation of the compressed tube.

We may now consider more particularly the chief symptoms and physical signs which indicate aneurism in the different parts of the thoracic aorta.

Aneurisms of the Root of the Aorta (*the Sinuses of Valsalva*).—Those aneurisms which spring from the very commencement of the aortic tube are not very uncommon. They are frequently entirely latent, but symptoms of pericarditis, or of angina pectoris, may occur. They are very liable to cause aortic incompetence. Such tumors are very dangerous, as, before arriving at any great size, they are liable to rupture, especially into the pericardium. Dr. Bramwell figures (op. cit., p. 720) a remarkable aneurism springing from this situation, and attaining an enormous size, perforating the sternum, forming a large external projection, and finally rupturing through the integument.

Aneurisms of the Ascending Portion of the Arch.—In this region of the tube, dilatations, cylindrical or spindle-shaped, are most frequent, but saccular aneurisms also occur. The latter are then generally situated upon the right side of the aorta. In an early stage of dilatation we shall find altered pitch of the percussion-note to the right of the sternal margin above the second rib, and the pulsation of the aorta becomes stronger and more perceptible above the sternum. As it increases, so we get more decided dulness, extending to the right above the second rib. The first sound becomes dull and the second more forcible and clanging. A systolic murmur may then become developed in the same area, which, from its seat of origin and want of diffusion, may be distinguished from a valvular murmur. Disease of the aortic valves frequently co-exists. Aneurism in the ascending arch has a tendency to reach the surface of the chest, and can, therefore, be generally easily made out by the physical signs. The locality where pulsation and bulging are most apt to be discovered is the neighborhood of the second costal cartilage of the right side. The edge of the sternum and one or two ribs become eroded, and the tumor, which may be of considerable size, projects. The pulse in the vessels of the right side will be small and delayed compared to those on the left, if the innominate be involved. Compression of the superior cava or right innominate vein may happen, with resulting dilatation of the veins of the upper half of the body or right arm. The symptoms commonly complained of are pain and dyspnœa, perhaps cough. When of considerable size, numbness and weakness in the right arm may occur from pressure on the brachial plexus. The right bronchus may also be sometimes compressed. Rupture of aneurism in this situation occurs most frequently into the right pleural sac, the pericardium, the lungs, or externally. In one of my own cases, already mentioned, rupture took place into the pulmonary artery.

Aneurisms of the Transverse Portion of the Arch.—These may be either spindle-shaped or, more commonly, saccular. As they occupy that portion of the arch of the aorta from which spring the great brachial and cephalic branches, the latter are quite frequently involved in the aneurismal growth. They are common, but somewhat less so than those of the ascending portion. Their situation is such that they, soon after attaining any size, necessarily impinge upon some of the important structures in the centre of the thorax, giving rise in consequence to decided evidences of intra-thoracic pressure. The presence of a pulsating tumor in this region will also cause easily recognized changes in the percussion of the sternum and its margins, and can further be detected by the sense of touch behind the manubrium. Aneurism in the transverse arch is therefore, as a rule, readily diagnosed except

when the tumor is quite small. Sometimes, even before any other signs have become developed, the aneurism may be discovered by means of the finger pressed well down behind the sternum in the jugular fossa. As the expansion of the aorta here increases it pushes aside the edges of the lungs, and dulness becomes well marked over the first piece of the sternum, and to a variable distance on either side of this. Then a heaving prominence makes its appearance in the same region, and, following upon the absorption of the sternum and upper ribs, an external tumor becomes developed which may even reach a large size. The radial pulses of the two sides quite frequently differ in size and fail to beat with the usual synchronism. This sign is more often met with in aneurisms of the arch, because here the innominate and subclavian arteries are so apt to have their calibre interfered with by pressure, by twisting or dilatation, or by the entrance of coagula. The parts most liable to compression in these cases are the œsophagus, trachea, recurrent laryngeal nerve, and the left innominate vein. If the concave border of the arch be also involved, the left bronchus is liable to be partially or wholly obliterated. The signs by which these various conditions can be recognized have been already considered. Rupture occurs into the trachea, the œsophagus, or pleural cavity, or more rarely into the mediastinum, the pulmonary artery, or one of the large veins.

Aneurisms of the innominate artery alone are rare, but we oftener see tumors of the arch associated with more or less considerable dilatation of the innominate trunk. The enlargement will be found beneath the right sterno-clavicular articulation and inner part of the first rib, and may extend into the neck beneath the sterno-mastoid muscle. In these situations we must look for the usual local signs, swelling, pulsation, and bruit. The latter may be heard up the carotid. The effect upon the distal arteries is generally well marked. The symptoms are chiefly pain, both local and more especially radiating up the right side of the neck and back of the head, sometimes down the right arm, with numbness; and if the tumor be larger, there will be signs of compression of trachea or œsophagus or an innominate vein. Cases sometimes arise where it is extremely difficult to determine whether the disease is confined to the innominate artery or occupies as well a portion of the arch at the origin of this vessel. For instance, a man came under observation a short time ago at the Montreal General Hospital, with a strongly pulsating tumor rising out of the neck above the right sterno-clavicular articulation. Dr. Fenwick, whose patient he was, believed it to be purely innominate. Its strict limitation to the area near this vessel, the distinctness with which the cylindrical tumor could be defined by the examining finger, the interference with the pulsations in the radials, and the absence of all signs of swelling of the arch, as determined by most careful examination, all seemed to favor this conclusion. This opinion was confirmed at a consultation of several members of the staff, and it was decided to recommend treatment by distal ligature. This the patient refused to submit to, and was discharged. He subsequently died suddenly, while running, from rupture into the pericardium of a small aortic dilatation just above the valves. The aneurism in question was found at the autopsy to be entirely aortic. A remarkably elongated saccular dilatation sprang from the arch directly behind the innominate artery (somewhat compressing it) and appeared above the inner edge of the clavicle. The innominate was completely pervious and of normal size. The deception was complete and would have given rise to a grave error of treatment had the patient consented. Although, as in the case just related, mistakes of this kind are sometimes quite unavoidable, yet in the majority of cases, a thorough investigation of all the symptoms and physical signs will suffice to make a diagnosis.

Aneurisms of the descending thoracic aorta are less common than the others. They also may be cylindrical or saccular. From the depth at which they are situated in the chest, and the thickness of the structures everywhere surrounding them, they are difficult of detection, and as the symptoms from them may be only slight and ill-defined, they may continue for a long time unsuspected. Pain is, however, seldom absent, and, if long continued, points strongly to aneurism. This point has been already sufficiently dwelt upon. The earliest physical signs consist in localized dulness to the left of the spine, and enfeebled breathing over the same area. Later on, a systolic bruit may be heard. Occasionally, retardation of the left femoral pulse, as compared with that of the radial, has been observed. When of large size, the aneurism pushes the heart forward, and the heaving impulse of the tumor can be felt anteriorly through the heart. A rare symptom is dilatation of the veins on the anterior aspect of the chest from pressure upon the azygos and intercostal veins. Lying against the vertebral bodies, these aneurisms very commonly produce erosion of those structures, if this be sufficiently considerable, bending of the vertebral column occurs, with posterior curvature. From this cause, or from opening of the vertebral canal, pressure is sometimes brought to bear upon the spinal cord itself, with a resulting paraplegia. The œsophagus is sometimes compressed, and dysphagia produced. Attacks of pleuritis in the lower part of the left side are a very frequent accompaniment. These usually result in plastic effusion, but, at times, even pretty considerable quantities of serum may be found. Some years ago I found a hospital patient complaining of stitching pain in the left side. Very moderate effusion was determined by physical examination. There had been slight pain in the back for some time previously, but this had not been of sufficient duration or intensity to lay stress upon. The fluid continued to collect, and was removed by aspiration, with relief. A few days afterward he died suddenly from rupture of an aneurism of the descending aorta into the same pleural cavity.

Rupture of these aneurisms occurs most frequently into the left pleural cavity, sometimes into the right, and occasionally into the œsophagus. Cases are known where the sac opened into the spinal canal.

Diagnosis.—The recognition of thoracic aneurism is just as easy in some cases as it is difficult in others. Superficial, strongly pulsating aneurisms are readily observed, and not unfrequently the throbbing will have been noticed by the patient himself. On the contrary, deep-seated dilatations may give no appreciable physical signs, when the diagnosis may be obscure. If one of these, at the same time, cause no symptoms by its pressure, then the diagnosis becomes impossible. Not a few aneurisms of the ascending arch, even of considerable size, prove the cause of sudden death in persons previously believed to have been in good health. These, having caused no symptoms, had never been looked for, but could undoubtedly have been detected by physical examination. The combination which gives the greatest certainty to the diagnosis of thoracic aneurism is the union of physical signs of tumor with pulsation in the course of the aortic arch, together with some, or best, several, of the pressure-symptoms enumerated. The difficulties in the diagnosis of these cases arise from the great variability which is met with in the manner in which these different indications may be grouped together. Thus we meet with cases where some of the physical signs of aneurism are observed, and no pressure-symptoms; others, again, where there are evident pressure-symptoms, with perhaps only a few of the signs of aneurism. In not a small number of cases the conditions lead to the recognition of an intra-thoracic tumor, and the difficulty only begins when we endeavor to differentiate between *a solid tumor* and *aneurism.* The simulation of aneurism by a solid tumor placed between the chest-walls and the aorta may be very close. Dulness, pulsation bruit will be found, and pressure-symptoms of identical character will occur. The chief points of distinction are the following: In the case of the neoplasm, the dulness is likely to be less clearly restricted to the aortic region, the pulsation will not be at all so forcible, the systolic bruit will probably not be followed by an accentuated second sound. Bronchial respiration commonly is heard over a solid tumor, while enfeeblement or silence is the rule in

aneurism. Again, persons with aneurism are not subject to suffer severely as to their general nutrition and appearance, while the contrary holds good with reference to nearly all forms of intra-thoracic solid growth. Attention to the following points may also assist the investigator in doubtful cases. Aneurism is many times more frequent than solid tumor. It occurs much more often in men than in women. It is favored by a history of rheumatism, strain, alcoholism, or syphilis. (Fifty per cent. of cases of aneurism have had syphilis.)

Pulsating empyema is a rare condition, which sometimes simulates aneurism. The chief physical signs to be here met with will be dulness on percussion and local pulsation, but no pressure-symptoms will be present. Examined closely, the dulness will be observed to be less clearly localized in the aortic region than that of an aneurism. Moreover, other signs of arterial disease will be wanting, and, on the other hand, there will be some evidences of disease in the pleura or the lung, accompanied by a certain degree of constitutional disturbance. These differences will usually suffice to avoid error. Puncture with a fine aspirator-needle would, in any case, clear up the diagnosis.

PROGNOSIS.—It is usually a matter of considerable difficulty to form a satisfactory opinion as to the prospects of life of a person suffering from thoracic aneurism. Undoubtedly the disease generally tends to prove fatal, and is actually the immediate cause of death in the majority of cases; and yet, in a certain number, increase in the tumor is arrested and moderate health is enjoyed for perhaps a period of several years, even then the fatal event being brought about by some affection entirely independent of the aneurism itself. It is often clearly impossible to estimate at all accurately the size of a deep-seated tumor, or the degree to which it may lie against important adjacent organs, and hence ruptures in various directions, which no skill could possibly foresee. Those aneurisms which arise from the root of the aorta are the most dangerous, as they tend most frequently to rupture while yet small. Those of the ascending arch—if they grow forward and to the right—are calculated to permit of the longest tenure of life. Those of the transverse arch and descending thoracic aorta are probably, on the whole, more favorable than the first and less so than the last; the reason for this, of course, being their greater proximity to numerous important structures, which can hardly escape from injurious pressure. Our opinion, therefore, of the probability of the prolongation of the patient's life must depend upon the situation of the aneurism, the fluidity or the contrary of its contents, and the presence or absence of symptoms of compression to a serious extent of the surrounding parts. If this be well marked upon the trachea or œsophagus, a fatal result may be anticipated before many weeks or months. Other conditions to be considered are the following: Mode of life; if a person with aneurism be obliged to earn his living, and especially if the occupation followed be at all laborious, his chances of living will be far less than those of his more favored fellow who may be able to live at ease and free from care. Rest is so important in these cases that if this cannot be secured the disease is almost sure to be progressive, and perhaps even to advance rapidly, while, on the other hand, it seems sometimes surprising how long the fatal end can be averted, even in advanced cases, by the observance of great precautions in this respect. This remark will also necessarily apply to the cases of patients who, from irritability of temper or other similar causes, refuse to carry out this essential principle of their treatment. The temperament of the patient is of importance, for anger, excitement, and, indeed, any violent reaction may be followed by the most serious results. Indulgence in alcoholic liquors is sure to interfere with the quiet action of the heart which is so desirable; intemperance must, therefore, influence strongly our prognosis.

Associated Conditions.—The existence of lesions, especially valvular, of the heart, of the lungs, of the larynx or bronchi, etc., must all be carefully studied and appreciated at their true worth as regards the future. Finally, the general condition with reference to nutrition, muscular development, digestion, etc., must also take its place in rendering the prognosis either more or less favorable.

TREATMENT.—Aneurism within the chest is capable of the same spontaneous cure which occurs occasionally elsewhere. Complete coagulation and hardening of the contents, with arrest of all symptoms, is, however, extremely rare. Still it is always obviously a duty to endeavor to place a patient, the subject of this formidable disease, in as favorable a position as possible for this process to occur. All treatment, therefore, which is not merely palliative, is directed toward insuring conditions likely to promote firm coagulation within the sac.

In the large majority of cases of intra-thoracic aneurism we are, from the nature of things, precluded from those methods of treatment which are applied directly to the tumor itself or its immediate neighborhood, and are frequently distinctly curative. We are, on the contrary, compelled to treat these cases by general measures and by such indirect means—drugs—as experience has proved to be of value. The objects in view may be briefly stated to be to reduce the tension within the aneurism, to secure regularity of the heart's action without frequency, to maintain the blood in good chemical condition without undue bulk, and to favor thickening of the sac's walls. To follow out these indications it is necessary to secure the full direction of the case for, perhaps, several months; to meet, therefore, with any success, it is absolutely requisite to have the hearty co-operation of the patient, who, if sufficiently intelligent, must be made acquainted with the nature of the case and the urgent need of his assistance, irksome though he may find it to be.

The recumbent position, for a length of time, is always to be recommended. The effects of this measure alone are often sufficiently striking. When the person's circumstances permit, the restriction to a lying posture should be absolute, and should be persisted in for several months, except the general health appear to be suffering materially from the close confinement, when, with due precautions, sitting up and slow walking may be permitted. If, on the other hand, circumstances prevent absolute rest from being carried out, then, at any rate, very stringent rules must be insisted upon, governing the patient's entire mode of life, with the view of insuring the least possible muscular exertion. This is a point on which too much stress cannot be laid. These patients live constantly on the edge of a precipice, yet when immediate suffering is relieved, this fact is too often lost sight of, with disastrous results. A patient whom I treated not long ago during a year for an aneurism of the ascending arch, was so far benefited that he took a situation as a messenger. In spite of all warnings to the contrary, he soon undertook to handle heavy baskets and other packages. One day, shortly after, sudden pain was experienced in the tumor, followed by the extraordinarily rapid development of an external tumor. This quickly attained the size of a child's head, and proved fatal, with great suffering. Hardly less important than physical rest is mental quietude. Habitual worries of all kinds should be as much as possible excluded, while actual excitement is in every respect highly dangerous. A fit of anger or other violent emotion may prove fatal, either by actually causing rupture of the sac or (as in a recent case of my own) from syncope.

The *diet* is a matter of importance. A very old treatment of aortic aneurism was that of Valsalva, in which repeated blood-lettings were practised together with a gradual restriction of the food until the amount of this was brought within the lowest possible limits short of actual starvation. The fallacy of this proceeding has, however, been long ago demonstrated. Blood-letting has but little, or but a temporary, effect upon the blood-pressure; and the withdrawal of food causes anæmia and weakness, with irritability of the heart and impaired nutrition of the arterial walls, which indirectly aggravate the disorder. The result of experience shows that the formation of coagulum, which is likely to be of service in the process, will proceed better if the patient be not too much reduced. Tufnell, of Dublin, is the only comparatively recent writer who has advocated the starvation plan.

Following his recommendation, the system has been extensively tried, but few are found who can report results calculated to lend support to its efficacy. As much nourishing food should be allowed as can be thoroughly digested, making due allowance for the weakened digestive activity owing to the enforced rest in bed. If the patient be plethoric and show evidences of congestive tendencies, then our treatment may well be begun by depletory measures for a time—a low diet with laxatives or saline purgatives.

As regards medicines, many have been tried but few have proved useful. The most valuable drug is undoubtedly iodide of potassium. The good effects of the iodide were described by Dr. Chuckerbutty in 1862, by Dr. Roberts in 1863, and emphasized and enlarged upon by Dr. George Balfour a few years later. Since that time it has been extensively employed, and has continued to grow in favor. The two former writers considered that it acted by inducing increased coagulability of the blood, but this view is not shared by Dr. Balfour. He considers that the iodide has "a peculiar action on the fibrous tissue, whereby the walls of the sac are thickened and contracted, while if coagulation should take place within the sac, it plays but a very secondary and unimportant part, depending for its occurrence solely on the remora of the blood, and is in no respect due to the iodide of potassium." This corresponds entirely with the results of my own observations, for in one case, where the relief to pain and general improvement had been very marked for a long time under this treatment, the autopsy subsequently showed that not a particle of fibrine had been deposited on the walls of the sac. Dr. Bramwell suggests that it acts by reducing the blood-pressure and relieving the tension within the sac. The symptoms which specially indicate the drug are pain and troublesome cough. The special pains of thoracic aneurism are generally very rapidly allayed, and are often for a great length of time held in abeyance by this agent; and the same may be stated with reference to the troublesome attacks of irritating cough which the tumor may excite from time to time. Independently, however, of its employment for the relief of these urgent symptoms, it is to be administered steadily for such a time as may be thought necessary to influence, as above, the disease itself. The dose usually given varies from ten to thirty grains thrice daily. Balfour, who formerly inclined to the larger dose, thinks now that fully as good effects can be obtained from smaller ones. His rule is to employ such a quantity as will lower the blood-pressure without increasing the frequency of the cardiac contractions. Beginning with ten-grain doses, ascertain the pulse-rate (the patient being recumbent), and increase to fifteen; if no increase in the pulse be observed, this is to be continued, but if the pulse gets quicker, then return to ten. It is rare that more than fifteen grains can be borne within the limits of this test. The treatment must be persevered with, at the least during several months, and to give it a fair trial, probably during a whole year, or even more. If troublesome eruptions are produced by the potash, an intermission must be allowed till this is recovered from. It is also well to remember that some persons who are thoroughly intolerant of iodide of potassium can take iodide of sodium without any outward effects. Dr. Balfour speaks truly when he says the results (from iodide treatment) "are extremely encouraging, and when we reflect upon the entire absence of any risk to the patient from the treatment, and the almost certainty of relief to his sufferings and prolongation of his life being at least attained, I think I am warranted in saying that no treatment for internal aneurism hitherto devised holds out anything like an equal prospect of relief, if not of cure, with that by the iodide of potassium."

Tannic acid and acetate of lead have both been given with a view to promote coagulation and favor contraction of the sac. No reasonable degree of success has followed in either case, even although the latter salt has repeatedly been pushed to the production of full toxic effects. I have tried it in one case of aneurism of the abdominal aorta, continuing its use until a deep blue line appeared on the gums, but without any noticeable change in the size of the tumor or the strength of the pulsations.

Ergotine, given internally (or by hypodermic injections), on theoretical grounds, to contract the vessel, has failed to produce any reliable results.

Mr. Christopher Heath and a few others have suggested and practised ligature of one or more of the great branches of the aortic arch, the object, of course, being to still further retard the blood-current and thus promote coagulation. Some support is given to this procedure from the benefit which has been observed in certain cases of aortic aneurism when the carotid and subclavian of the right side had been ligatured, under the impression that the disease was confined to the innominate artery. At most it would only be applicable to cases where the tumor was sacculated and either involving the root, or situated close to the origin of some of the great vessels. Evidence of extensive atheromatous disease would shut out any prospect of advantage from this surgical procedure.

Attempts have also been made to produce rapid coagulation of the blood within the sac by the introduction therein of foreign bodies. Fine iron wire, watchspring, and horsehair have been employed for this purpose. The results, however, have been more or less disastrous. The coagulum thus formed is soft or friable, and consequently very liable to the detachment of emboli, and moreover is actually loose in the centre of the sac, instead of being regularly laminated upon its sides. Inflammation of the sac is liable to occur, and as there is no means of keeping this within the bounds of safety, may itself cause dangerous symptoms. The principle seems faulty, and the absence of good results has caused the treatment to be abandoned.

There still remains to be mentioned a form of treatment which has seemed to be of service in a few cases of otherwise desperate character. That is *galvano-puncture.* The use of electricity in this way is only permissible after a fair trial for a sufficient length of time of complete rest and iodide of potassium. It is advised in sacculated aneurisms which are situated near the surface of the chest, have resisted treatment, are rapidly enlarging, and threaten soon to rupture. This method, in suitable cases, has met with a certain measure of success, but it has much more frequently failed of its object, in some instances even having caused dangerous inflammation of the sac, and in others hastened the occurrence of rupture. For galvano-puncture it is necessary to employ a battery of considerable strength, the Leclanché or Stöhrer element being what is generally preferred. Experiments have been made with one needle only or with both introduced within the sac. From these it seems generally admitted that it is necessary only to pass in one or two needles connected with the positive pole, while the negative is attached to a flat metallic electrode on the surface of the abdomen. It is recommended either to continue the current for a short time only, say twenty or thirty minutes, by which a small clot will be formed to constitute a nucleus for further deposition; or else to allow the current to pass for a time sufficient to coagulate the entire contents of the aneurism, say two or three hours. It may be necessary to repeat the operation after an interval of some days.

Although the special treatment of thoracic aneurism in the majority of cases consists of prolonged rest and the administration of iodide of potassium, as above detailed, there are besides these certain therapeutic measures at our command for the relief of individual symptoms.

Excited cardiac action and palpitation is best relieved by the judicious use of tincture of digitalis and the employment of a bladder of ice over the front of the chest.

The pain, it has been already stated, is generally best treated by the iodide of potassium. If, however, it be very severe, it may be necessary to use hypodermic injections of morphia, until the iodide shall have had time to act. Moreover, we do meet with rare cases where the effect of iodide ultimately becomes lost, and our only resort is the frequent use of morphia to make life bearable. One very marked case of this kind came under my notice in the person of a hospital patient. His aneurism

was as large as a cricket-ball, and almost as solid. Neuralgic pains were complained of persistently, were relieved for a considerable time by iodide treatment, but, for more than a year previous to his death, we were obliged to administer daily hypodermics of morphia in considerable quantity. Pain of well-defined neuralgic character (especially the intercostal) is decidedly benefited by the application of small blisters over the most tender parts.

Dyspnœa, if due to accompanying catarrh, must be treated with reference to the latter disorder. But if, as is most frequently the case, it is the result of mechanical pressure and irritation of nerves, recourse must be had to sedatives and narcotics, especially morphia and hydrocyanic acid. Alcohol in tolerably full doses is also of considerable assistance.

If a projecting tumor form, care must be taken to protect it from injury or friction by some arrangement of pads or a shield of some smooth metallic substance lined with cloth.

When rupture has actually taken place, we can probably do nothing; but, if any preliminary bleeding should occur, we may endeavor to prevent this going on to rapid hæmorrhage by the use of ice externally and the administration of astringents with ergot, while the most perfect quietude is enjoined. *George Ross.*

ANGELICA. (*Radix Angelicæ*, Ph. G.; *Angélique officinale*, Codex Med., root and fruit; *Archangelica sativa* Bess.; *A. officinalis* Hoffm.) The source of the above is one of five species which have been separated from the older Linnæan genus *Angelica*, on account of their having numerous oil-ducts, or *vittæ*, in the fruit, instead of six, as in typical *Angelicæ*. By Baillon all are included together. They are large, rank-growing, strong, but not exactly unpleasant-smelling umbelliferæ, inhabiting the colder parts of Europe and America. *Archangelica sativa* grows one and a half or two metres (four to six feet) high, from a large, fleshy, biennial root, and has a smooth, fluted, purplish, hollow stem. The fruits are large oval, flattened, narrowly winged at the sides, with a loose, separable epicarp; the endocarp, with about twenty *vittæ*, is attached to the seed. Garden angelica is a native of Europe, from Prussia to the North Cape, growing further south in elevated districts. It is also found in Northern Russia and Siberia, as well as in Iceland and Greenland. It has long been cultivated in Europe, and is occasionally found in gardens in the United States, from which it now and then escapes The commercial supply is from the plant cultivated in France and Germany.

It is one of the few vegetables whose use began in the extreme north of Europe, and extended southward. It was an article of food in Norway and Iceland many years ago, when its spicy taste made it a grateful addition to the monotonous diet of the North. Later, in the fifteenth and sixteenth centuries, it was generally cultivated throughout Central Europe. Since then, the use of angelica has been gradually diminishing, milder flavored vegetables taking its place, and it is only grown at present to fill a very moderate demand for it in domestic and veterinary medicine, confectionery, and *liqueurs*.

The root consists of a large short rhizome, terminated above by a hollow stem, and often worm-eaten. Below, it divides into numerous thick, fleshy roots, one centimetre (one-third of an inch) in thickness, and twenty or thirty in length, of a brownish-gray color, much wrinkled longitudinally, and tuberculated. They are rather soft and pliable, brownish-white within, and in the dried specimens lie in a parallel tress or bunch. The odor is rather pleasant; the taste at first sweetish, later bitter and musky. Radially arranged oil-, etc., ducts are to be seen under the microscope on section, chiefly in the cortical portion.

The principal constituents of angelica are, first, an *essential oil*, of which it yields from eight-tenths to one per cent.; this has the odor of the plant and the usual carminative qualities of the oils of the order. Secondly, *angelic acid*, one-third of one per cent., discovered by Buchner in 1843, and since found in a number of other plants, as well as made by synthesis; an odorous crystalline volatile acid, nearly insoluble in water, but readily so in alcohol, ether, or chloroform. Thirdly, a minute quantity of *valerianic acid*. Finally, *angelicin*, and a bitter principle.

Angelica is an agreeable aromatic, and like the roots of many other umbellifers is also quieting and antispasmodic. It is not to be reckoned among active medicines, but would be a useful aromatic adjuvant to others, if we had not so many of its kind. Its dose is naturally an indefinite one, but from one to three grams (grs. xv. ad grs. xl.) would be pleasantly carminative, and certainly not dangerous. A hot infusion (one-tenth) or an alcoholic extract would be appropriate forms, the latter pharmaceutically the most perfect.

Allied Plants.—*Archangelica atropurpurea*, Masterwort, common in the United States; *Angelica sylvestris* Linn.; *Levisticum officinale* Koch, of Europe, and other nearly related plants, have sometimes been used as substitutes. They have similar qualities, but are ranker and more disagreeable in flavor. For further relations see Anise.

Allied Drugs.—See Assafœtida. *W. P. Bolles.*

ANGINA PECTORIS (ἄγχω, I suffocate, and *pectus*, breast). An idiopathic or a symptomatic neurosis characterized by sudden sharp pain in the chest and a sense of impending death.

Various other terms have been proposed by different authors, who have named the affection in accordance with their anatomical notions of its seat in the heart, lungs, diaphragm, and even the sternum, its supposed connection with other diseases, and its analogy with attacks of asthma or syncope. Among these antiquated names are cardiagmus cordis sinistri, convulsive asthma, asthma dolorificum, diaphragmatic gout, arthritic asthma, syncope anginosa, pneumonalgia, pneumogastralgia, sternocardia, sternalgia, and the like, all of which have been treated in a voluminous way by their respective observers, with more or less obscurity and discrepancy. The most generally accepted term, angina pectoris, is one sanctioned by usage, and merits to be preserved, since it presupposes nothing of the nature of a much discussed affection.

Such ancient authors as Aretæus and Aurelianus seem to have observed the symptoms of angina pectoris, and in the chronological abridgment of Mézeray there occurs the history of a case in which well-marked symptoms of angina pectoris are mentioned. The historic cases of Seneca, John Hunter, Arnold of Rugby, Dr. Chalmers, John Leech, and of Charles Sumner are familiar to most medical men. It was not, however, till toward the end of the eighteenth century that facts noted in connection with the subject were authentically observed and clearly described almost simultaneously in France and in England. Since then many vivid descriptions of angina pectoris have been given by various writers; but the study of the complaint leaves several points to elucidate upon which there is more or less discord among authors that have treated the subject.

Clinically speaking, the diagnosis of a typical case of angina pectoris is easy, although the principal symptoms of the disease are mostly subjective. Affections with which it is liable to be confounded are the cardiac pain of aneurism; the angina-like pain in cardiac neuroses common to hysteria, sexual hypochondriasis, or excessive use of tobacco; and the intense and persistent pain of cervico-brachial neuralgia in chronic basilar meningitis. It requires but little diagnostic acumen to differentiate the pain of biliary calculi from this affection, and in spasmodic asthma there is rarely present that unspeakable sense of sudden death. The constant phenomena of the disease are sternal pain with a feeling of anguish and of sudden death. No pain can compare with that of cardiac angina. In no disease is there such real physical agony and such keen anxiety. Words are hardly required to make the diagnosis clear to the observer. The pain, paroxysmal in character, comes on in attacks more or less remote, at irregular intervals, and may last from a few minutes to several hours. Its greatest intensity is at the seat of election, the heart, whence it irradiates,

in extremely severe cases, in all directions, up, down, and sidewise to the left side of the neck, to the left shoulder, and to the maxillary region, to the intercostal spaces, and down the left arm. In exceptional cases, where the lesion of the cardiac nerves is not limited to the left ventricle, it extends to the occipital condyles, both shoulder-blades, the finger-ends, and down the right arm, or even to the lower extremities. In women extreme sensibility of the breast is sometimes a symptom. Each patient has a particular term to describe his sensations. They have been compared to a stab in the heart, to a sword plunged into the sternum and left side of the neck, to the sudden thrust of a hot iron into the heart, to strangling and suffocation, and to the sudden grasp of an icy hand, which gradually tightens until it feels like a clasp of steel crushing the heart to atoms. The indefinable anguish that follows the local violence and puts death before the eyes, is stated to be like the anxiety felt by a drowning person. At the outset of an attack, the patient instinctively places his hand over the seat of pain, terror is depicted on his pallid countenance, he is insensible to surroundings and afraid to move, but the integrity of the intellect is perfect: in anomalous cases only have cerebro-spinal symptoms been noticed. The patient tries by strong inspirations and deep sighs to increase the capacity of the chest, which feels as if being squeezed in a vise. The respiratory phenomena, however, are not uniform in character. There is seldom actual difficulty in breathing, and auscultation or percussion reveals nothing, but the chemistry of respiration is usually impeded. In some cases a suspirous respiration, or that peculiar form of dyspnœa, the so-called Cheyne-Stokes respiration, is observed. The patient sometimes experiences the sensation of a foreign body in the air-passages. The circulatory symptoms are somewhat variable. Except in cases of cardiac complication, the pulse preserves its regular rhythm, but some observers report intermittence, irregularity, feebleness; and the sphygmic perturbations of the attack indicate tension of the systemic arteries. Cardiographic tracings are said to show diminution of the amplitude of the pulse-wave, with blunting of the apex, slow or greatly postponed recoil, and obliteration of the dicrotic wave. The patient's phonation and deglutition are interfered with during an attack. He speaks but little, and that like one suddenly surprised, full of fear and intent on himself only. The stomach is often sympathetically affected, giving rise to eructation, vomiting, and sometimes to difficult digestion. Several writers report malaise of the bladder, with a desire to micturate often; but state that no morbid changes in the urine are to be detected by means of reagents. Strangury, ilio-scrotal neuralgia, and swelling of the left testicle have also been noted in patients with gouty or rheumatic antecedents, or with some coarse pathological change of the heart. If the patient do not die from syncope in the middle of an attack, as more than half of them do, it passes off with a profuse perspiration, and the escape of flatulent air from the stomach, disappearing as suddenly as it came on, leaving the exhausted patient with a desire to sleep after the terrible ordeal through which he has just passed.

Following the attack there may be tremor with slight loss of motion and of sensation in the affected arm, and the nervous phenomena may extend to the skin of the precordia. In some cases visual troubles, insomnia, and the dreams peculiar to heart troubles, follow. Recovering from exhaustion after some days, the patient is restored to his previous condition of health. As the disease advances the attacks become more frequent and violent, and more easily brought on, until one of them ends life.

Happily for mankind, cardiac angina is a rare disease; and it occurs chiefly in men, among whom it is ten times more frequent than among women. It has been observed in an epidemic form in two notable instances; once in Germany and once on board a French man-of-war, where it was owing to the action of such general causes as bad hygiene and the excessive use of tobacco. Many authorities state that angina pectoris is a disease common to men that have passed the age of forty; but the influence of age as a causative factor is far from being so absolute as is pretended, since cases have been reported to occur in young men of twenty-one and seventeen, and in England and in France cases of angina pectoris are reported to have been witnessed even in infants. It has also been noticed in women at the menopause. Nor is the influence of heredity of such a negative and indefinite nature as some would have us believe. Reversions to ancestral forms, and the tendency in parents to transmit temperament and infirmities to their offspring, are reasons for believing that atavistic antecedents should be taken into account when considering the predisposing causes. More convincing, indeed, is the recorded case of a soldier who suffered from angina. His father had died from the disease, also his sister and two brothers. Other cases of the kind occur in medical literature.

People of quiet, sedentary professions, and in affluent circumstances, are said to furnish the principal contingents to this disease; and climate, seasons, and regimen play a certain part in its development. It is more common in the British Isles and among the Teutonic races than it is in France, Italy, or Spain. Its place of predilection is Ireland, which passes for the country where heart troubles are the most frequent, and it must not be forgotten that daily altercations are almost the hygiene of the Irish. Excessive indulgence in tobacco is a causative factor. Eight cases of nicotinic origin are described in which the attacks ceased when smoking was stopped, and returned when the patients began to smoke again. Analogous cases are reported by at least four eminent authorities. Depression of the arterial system, produced under the influence of nicotine, and observed microscopically in the interdigital membrane of a living frog, is not without its lesson to the medical man. A direct inference is to be made from the arythm of the heart, followed by contraction of the coronary arteries, producing a vasomotor spasm in organs that we know to be the point of departure of the malady in question.

Tea, alcohol, and tobacco, all of which are largely used by northern races, are three prominent causes of angina pectoris. To these may be added the harmful influences of cold and damp residences; the reflex impulses arising within the body from thoracic or from abdominal disease; the influence of other diseases, notably anæmia, and the vaso-motor disturbance of persons suffering from lithiasis; the predisposition brought about by previous attacks; by organic affection of the heart, and by the state of the stomach. Sciatica has been known to replace angina pectoris, which disappeared when this malady showed itself; and vegetable colic and angina pectoris have succeeded and replaced each other turn by turn, the former appearing when the latter disappeared.

Among the occasional causes are anxiety, sudden anger or joy, hunger, walking or riding against a cold wind, walking up an inclined plane, straining at stool, and, in fact, everything that acts either directly or indirectly on the heart by accelerating its movements may cause an attack. Running after a street-car produced an attack in Mr. Sumner, who, by the way, was an inveterate tea-drinker. He had other attacks on turning suddenly in a revolving-chair, and in bed after a sound night's sleep, when no definite exciting cause for them could be assigned; but the violent excitement and gesticulation of political speech-making never brought on an attack.

Idiopathic and symptomatic are the varieties usually spoken of. There is a disagreement among nosologists as to the so-called pseudo-angina, a comparatively trivial and inorganic form, the practical clinical utility of which is even doubted; so it will be passed over to the cardiac neuralgias and dismissed as a distinction too subtile to be discussed at the present time.

To reproduce and discuss even in outline the various opinions on the nature of angina pectoris since 1768, would only complicate without profit its study. Two classes of opinions are now held in regard to it; one having relation to an organic and material lesion of the heart, the other to a nervous affection or functional perturbation. Ulcer of the mediastinum or inflammation of the mediastinum; fat in the mediastinum and pericardium; ossifi

cation of the costal cartilages; persistence of the thymus, and cardiac changes, the principal being ossification of the coronary arteries, have been successively mentioned as anatomical alterations characteristic of angina pectoris. The second group of authors, principally German, saw in the disease one of the manifestations of the rheumatic or gouty diathesis. An Italian theory, forgotten to-day in Italy where it originated, makes angina pectoris depend on organic lesions of the abdominal organs, principally on hypertrophy of the liver, while others assign aortitis and cardiac ischæmia as the most common causes of symptomatic angina pectoris. The theories that regard it as a hyposthenia or a syncope, or as an intense and intermittent asystole provoked by a cardiac neurosis, have been questioned. The theory adopted to-day regards the malady as a neuralgia of the cardiac plexus, sometimes idiopathic, at others symptomatic of lesions of the heart and of the great vessels. The opinion generally admitted is that the disease is sometimes a simple syndroma dependent on structural lesion of the heart or other organs, and at others a simple neurosis or a neuralgia not owing to any appreciable lesion. Gleanings from numerous works written on the subject incline one to believe that many of the old necroscopic observations are untrustworthy. Not having the modern instruments of precision to aid in research, the results of the examination are more or less incorrect; and quite naturally led to bad interpretations and to conclusions purely hypothetical. Where cardiac lesions were found the authors have sought in the lesions found after death the reason of the symptoms observed during life. The principal necroscopic observations have been limited to lesions of the coronary artery, the aorta, and the cardiac muscles. Aortic insufficiency, aneurism, and fatty or other degeneration of the heart-muscle, are the principal anatomical lesions reported by the older writers. Changes in the nervous apparatus of the heart have been noted by late observers, who have found microscopic evidences of inflammation in the cardiac plexus. Some suppose the primary lesion to be in the spinal cord. Whether this be true or not, it is known that the starting-point of angina is most often in the domain of the pneumogastric, that is to say, it may be cardiac, gastric, or pulmonary. A lesion of the terminal branches of the coronary nerves may cause an acute distention of the heart, the keen pang from which may be reflected by way of the sympathetic branches of the cardiac plexus and the spinal cord to other points of the periphery, and extension may take place to all parts of the body.

A patient with cardiac angina scarcely needs to be reminded of the gravity of his symptoms, since he can in a measure foreshadow his ultimate fate. The prognosis is favorable in cases originating from tobacco, cold, or reflex of the vagus, provided the cause be removed. Generally speaking, where there is an organic complication the danger is greater; but typical cases of angina pectoris have been known to survive for twenty years or more. The writer recalls the case of his father, who died suddenly just after going to bed. In some patients the disease has so far abated in severity and frequency that they have been able to lead active lives, to indulge in mountain climbing, and to go on long journeys; and in the earliest literature of the subject is mentioned a case of Heberden's angina, in which there was an approach to a cure, where the patient had prescribed to himself the labor of sawing wood for half an hour every day.

If angina pectoris be symptomatic there is but little chance of a cure. During an attack a few whiffs of ether or chloroform may be carefully inhaled, or what is better, a few drops of nitrite of amyl placed on a handkerchief or a piece of blotting-paper. It is recommended that patients should also carry some of this remedy, which may be had in glass capsules. A paroxysm coming on, it is only necessary to break one of the capsules in a handkerchief and inhale. Although nitrite of amyl is not a specific, it is useful in those cases where there is increased blood-pressure in the arteries. The administration of this drug was suggested from the physiological fact, established with some degree of certainty, that a relation exists between increased arterial tension and cardiac angina. Nitro-glycerine is valuable in relieving the paroxysm and also as a preventive. It may be given in the form of a lozenge containing the one one-hundredth part of a grain, or in drop doses of a one per cent. spirituous solution. Some patients obtain relief in certain positions, for instance, when the head is thrown back and the spine strongly extended as in opisthotonos. How and why this position brings about relief is not known, any more than the fact that pressure on the spinous and transverse processes of the cervical and upper dorsal vertebræ or the regions of the inferior angle of the scapulæ excite and increase the severity of an attack. Placing the feet in hot water is a valuable adjunct to the treatment. Dry friction, hypodermic injections of morphia, dry cups between the shoulders, with the administration of stimulants and anodynes are also useful.

After the paroxysm there should be an examination of every organ and every function, and a search made for all the causes of deranged general health. Nitro-glycerine should be given for several days if the arterial tension be high; general measures applicable to the treatment of chronic conditions and of the cardiac or arterial lesions that happen to be present, may be adopted, and the strictest personal hygiene should be pursued. A nutritious diet, consisting principally of vegetables and milk, is to be recommended, and, where practicable, the grape cure. The disease has been known to be suppressed and arrested, and even to disappear, on interdicting the use of tobacco. It is reported that surprising effects have been obtained from using two highly magnetized steel-plates of a line in thickness, and so shaped as to conform to the regions under the left nipple and the left shoulder-blade. The actual cautery to the inner side of the thigh has been highly extolled. But electricity is perhaps the best of these remedial agents. Recent authorities speak highly of galvanism, and claim also to have cured angina pectoris by the local application of the faradic current. Electric treatment has proved so useful in angina pectoris that it is now looked upon as the only direct remedy.

Ferruginous and arsenical preparations, and quinia with musk, are among the medicaments most worthy of mention. If there be a gouty or rheumatic diathesis, it should be met by appropriate treatment, and a suspicion of syphilis should be likewise suggestive. Sea-baths and travel are to be recommended; the patient should avoid all commotion, moral and physical; he should lead a quiet, cheerful life, and should religiously abstain from tea, alcohol, and tobacco. *Irving C. Rosse.*

ANGIOMA. The angioma is a tumor which is entirely, or for the greater part, composed of blood-vessels. The blood-vessels composing the tumor are mostly of new formation, though the vessels of the part where it is seated may enter more or less into its formation. When this is the case, the normal vessels become altered, and take on the character of those forming the tumor. Other pathological products, which should not be reckoned with these tumors at all, have frequently been confounded with the angiomas; as, for instance, the various hæmatomas and some forms of aneurism, especially the aneurysma racemosum and the varix racemosum. These latter depend simply on the dilatation and hypertrophy of already existing vessels, and have no connection with structures whose tissue is entirely or for the most part of new formation. The angiomas have also been designated erectile tumors, from their analogy with the corpus cavernosum and other erectile tissues. The size and consistency of the same tumor may vary much from time to time, such variation depending on the degree of their distention with blood. When from any cause the blood-supply in the tumor is lessened, it may be soft and flaccid, to become firm and elastic again when in a hyperæmic condition. In women it has been noticed that these tumors are most distended and prominent during the menstrual period. The angiomas have been divided into two varieties, the angioma simplex and the angioma cavernosum; a division justified not solely by difference in structure,

but also by the observed lack of identity between the favorite site of the one variety and that of the other.

The angioma simplex is a tumor which consists of vessels analogous in structure to capillaries and very small veins. These vessels are very tortuous, and have thicker walls than vessels of corresponding size in normal tissues. Small, irregular varicose dilatations at intervals are very frequently seen. Both the vessels and the tissue in which they are embedded contain abundant nuclei. These tumors are very common, are nearly always congenital, and are most frequently situated in the skin. From observations made by Depaul it is found that one-third of all the children born in the clinic of the Faculty of Medicine in Paris have such angiomas at birth. They constitute the small vascular nævi and most of the so-called mother's or strawberry marks, and may be from the size of a pin's head up to that of the hand, or may even cover the skin of a whole extremity. Usually they do not project above the surface of the skin, though they may form considerable projections, and may even take on a polypous form. According as to whether the circulation in them is active or slow, they have either a cherry red or a dark bluish color. Their color depends also in part upon the distance below the epidermis at which they are seated; usually their seat is in the dermis, but they may be found in the subcutaneous cellular or adipose tissue. On examination it is seen that they are composed of small lobules from the size of a pin's head up to that of a pea, and on microscopic examination, after an artificial injection, we find that these lobules correspond with the vascular districts of the sweat- or hair-follicles. The accompanying cut represents such a lobule formed about a sweat-gland (Fig. 171). Most of these tumors, when seated on the skin, can be emptied by pressure, and slowly fill again when this pressure is removed. When the tumor contains, along with the vessels, a considerable amount of connective or adipose tissue, it is not possible to press the blood from it.

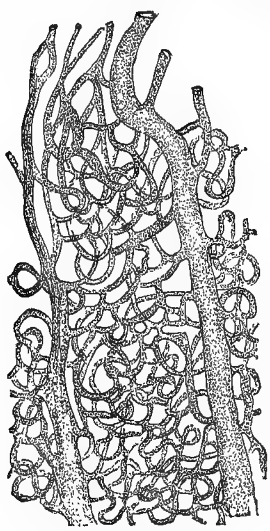

FIG. 171.—Artificial Injection of an Angioma Simplex of the Skin. The vascular area of a sweat-gland. (After Billroth.)

The cavernous angiomas differ in many respects from the other forms. On extirpation they can be recognized on section because they offer an appearance identical to that of the corpus cavernosum penis. We find a firm, tough, white mesh-work, which appears in the fresh state either empty or filled only with some irregular blood-clots. The meshes frequently enclose small round calcareous masses known as phleboliths. In some cases this cavernous structure is sharply circumscribed and separated from the sound tissue by a firm capsule. In other cases, where the tumor is small and to all appearances in a state of rapid growth, it is surrounded by a zone of small-cell infiltration. In all cases the connective tissue of the mesh-work is rich in nuclei and contains many lymphoid cells, either scattered singly through the tissue or in groups. Generally these tumors are single, in some cases, however, several small tumors will be found in the immediate neighborhood of a large one. The mesh-work is in some cases thick and strong, in others represented only by very thin partitions between the large spaces. It consists of connective tissue, which is in part the old tissue which was replaced by the tumor, in part it is newly formed. The inner wall of the spaces is lined by flat endothelial cells. These spaces, no matter how large they may be, always represent capillaries, for they are intervened between an artery and vein.

There have been various views respecting the genesis of these cavernous angiomas, and at one time they formed a ground of contention between two of the greatest pathologists, Virchow and Rokitansky. Virchow alleged that an inflammation and hyperplasia of the connective tissue always preceded them, and that they were formed by the dilatation of the newly formed vessels in the area of small-cell infiltration. Rokitansky, on the other hand, did not regard the spaces filled with blood as true vessels, but supposed that they and the blood-corpuscles which they contained were formed independently in the connective tissue, and afterward came into communication with the blood-vessels. The blood-corpuscles he regarded as formed by an endogenous process within certain altered connective-tissue corpuscles. These he called "Hohlkolben," and described them as large protoplasmic masses seated usually along the vessels. The whole tissue of the spaces filled with blood he regarded as analogous to the cylinders of epithelial cells in carcinoma, and the mesh-work represented the stroma. These views of Rokitansky found confirmation in a description from Luschka of such structures seated on the small vessels of the brain. E. Newman also reported a case of naso-pharyngeal polypus which, in part, consisted of a

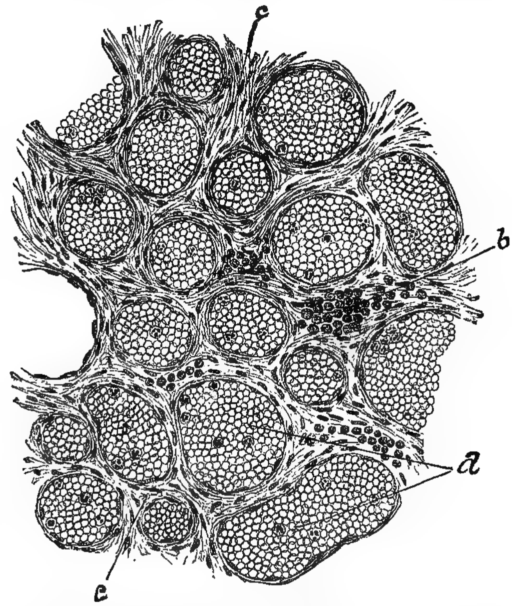

FIG. 172.—Angioma of the Liver, Hardened in Alcohol and Stained with Bismarck Brown. *a*, Cavernous spaces filled with blood-corpuscles; *b*, small cell infiltration; *c*, *c*, stroma. × 75.

cavernous tissue, and in the portion of the tumor between this tissue and the adjoining fibrous tissue he found a network of spaces filled with blood-corpuscles which had the shape of the lymphatic network, and which passed into the cavernous structure. Stricker and a number of other authors, followers of his peculiar school, have described such a formation of blood-corpuscles in the connective tissue in inflammation; so that there seems some ground even now in support of Rokitansky's views. We know, however, that the so-called blood-cysts of Luschka are nothing but the dilatations of the perivascular sheaths of the cerebral vessels. Newman's case evidently was nothing but a hæmorrhage into the tissue, and Stricker has never brought forward any evidence that should warrant us in regarding his views of blood-corpuscle formation in inflammation as correct. Rindfleisch has advanced another view as to their formation. He says that they depend upon the dilatation of old vessels, and that this dilatation is in many cases

caused by the contraction of cicatricial tissue in the same way as the bronchiectatic cavities in the lungs are caused by the contraction of the indurated lung-tissue around them. This view can hardly be regarded as tenable, since the tumors cannot be shown to stand in any relation with the presence of such a tissue. In the lung, where we most often find such tissue, an angioma is scarcely ever seen, and in the liver, where they are so frequent, they cannot be shown to stand in any relation to cirrhosis.

These cavernous angiomas are most often found in the liver, where they form dark masses, generally seated directly beneath the capsule and never elevated above the surface. They vary much in size; some are not as large as a pea, others may occupy the whole or the greater part of a lobe. Generally they are single, but sometimes a great number are found. In almost a majority of the livers of old people they are found, and their frequency would seem to vary in different countries; according to the report of pathologists they are not so frequent in Norway and Sweden as in Germany. By excising the tumor with the surrounding liver substance, and then hardening the whole in alcohol, a beautiful natural injection of the tumor may be had. Fig. 172 shows a section of a small liver angioma treated in this way, and may be taken as a type of the cavernous angioma. By bursting of the vessels of large tumors through the capsule, extended hæmorrhage into the peritoneal cavity, and fatal peritonitis has been caused.

Such tumors are also found in the other abdominal organs, as in the spleen and kidneys, though they are nothing like so common as in the liver. They are not so frequently found in the skin as are the simple angiomas. Esmarch has reported in *Virchow's Archiv* a very interesting case of their appearance here. A single tumor developed on the middle-finger of a girl of eight years, followed in subsequent years by the appearance of a great number; at the time of the first menstruation there was a great increase both in number and in size. At each succeeding menstruation they seemed to grow more than at any other time. In size they varied from that of a pea to that of a hen's egg. They were all successfully extirpated, and in most cases found to be seated on the wall of a vein with which they were in communication. Fig. 173 shows two of these tumors after artificial injection from the vein. The case is of especial interest as showing that, even in the case of the veins, we have the tendency of a particular system of the body to be affected by tumor formation.

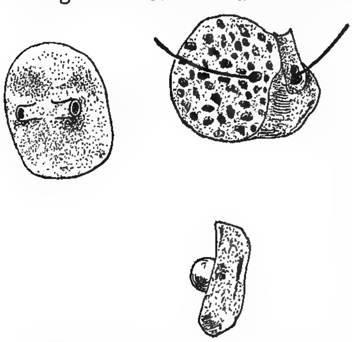

FIG. 173.—Cavernous Tumors Seated on Wall of Vein. (After Esmarch.) Natural size.

The angiomas may lead to a fatal termination by what may be regarded as the accidents of their growth, but in general they may be regarded as benign. Their growth is always central; they show no tendency to infiltrate surrounding tissues, nor do they cause metastases. They may cause death from hæmorrhage and by the pressure which they exert on surrounding parts, when these are important, as in the case of the cranial bones. Cases have been reported where they have followed the course of malignant tumors, in that they have invaded surrounding parts and have caused metastases. But in these cases it is more than probable that a sarcoma with dilated blood-vessels was mistaken for the angioma. This mistake is sometimes made. The pulsating tumors of the long bones, which have been described as cavernous tumors, are only telangiectatic sarcomas.

The majority of all angiomas are congenital; when they do develop after birth it is generally in the early years of life. It is seldom that such a tumor develops after adult years, which is remarkable in view of the frequency of vascular dilatation in old age. This fact alone is much against the view which ascribes the angiomas to a simple dilatation of pre-existing vessels. Angiomas have an interest in that their presence on children has been referred by the ignorant in all ages to some influence exerted on the mother while she was carrying the child. They have played an important part in romantic literature, as the strawberry marks which lead to the identification of lost heirs, etc. Inheritance would seem to play some part in their production. Cases have been known, again and again, where they appeared in the child in the same spot as on one of the parents. Their growth is in general slow and painless; the surrounding tissues are pushed aside to make room for them. Their growth is irregular; cases have been known to reach a certain size and then remain stationary, in other cases it is constant. Billroth cites a case where a cavernous angioma, seated on the neck of a child, in five years reached a volume the size of a man's fist. They may sometimes undergo spontaneous cure by the very process which is found so dangerous in other tumors, *i.e.*, by ulceration of the skin over them. A cicatricial tissue is thus formed, which includes the vessels and abolishes them by its contraction. Sometimes, when the tumor is connected with the skin by a pedicle, as may be the case, the vessels in the pedicle shrink, and the tumor dries up and drops off. In other cases cure may be effected by the formation of a thrombus, which shuts off the circulation. *W. T. Councilman.*

ANGUSTURA (*Cuspariæ Cortex*, Br. P.; *Angusture vraie*, Codex Med., etc.).

Galipea Cusparia A. St. Hil.; *Cusparia trifoliata* Engler; order *Rutaceæ*, whose bark is above named, is a shrub, or small, slender tree, with compound leaves and handsome white flowers, growing in the Orinoco Valley of South America. Its identification has been difficult, and it has been successively named *Angustura*, *Bonplandia*, *Cusparia*, and *Galipea*. The genus in which it is here placed includes about twenty tropical shrubs or trees with usually fine, showy flowers, and compound and fragrant leaves.

The bark of Galipea Cusparia has been in use about one hundred years, not counting its employment by the aborigines before its introduction into European medicine. It is collected in the northern part of South America, in Columbo and New Granada, and exported principally from Angustura, from which town it takes its name. It is shipped to the West Indies, and again reshipped to Europe. It comes in short, flat pieces, often considerably broken; apparently pared with a knife from an adhesive stem, and having, consequently, bevelled edges and ends; sometimes chips and splinters of the wood are attached to the inner surface. It is seldom more than three to five millimetres (one-eighth to one-fifth of an inch) in thickness, or from five to fifteen centimetres (two to six inches) in length. The epidermis and corky portion are yellow-clay colored, slightly uneven and so soft as to be easily scraped and cut with the nail. The inner part of the bark is hard and brittle, and separated from the above by a brownish line of stone cells. It is of a yellowish or reddish brown color and contains calcium oxalate crystals and numerous oil-cells. The odor is peculiar, and is disagreeable to the taste, being bitter and spicy.

The two principal constituents are an *essential oil* and an alkaloid. The former has been obtained to the extent of from two- to four-fifths of one per cent., the latter, *angusturine*, was discovered by Oberlin and Schlagdenhauffen, and obtained in prisms. *Cusparin*, an active principle previously described by Saladin, has not yet had its existence and character established.

ACTION.—Angustura is a stimulant aromatic bitter; in large doses it is said to be cathartic. It has been given for debility with dyspepsia, for intermittent and for chronic dysenteries and diarrhœas. In the United States it is scarcely ever prescribed.

Dose, one-half to three grams (gr. viij. ad gr. xlv.) in infusion.

ALLIED PLANTS.—See Rue, oil of, for notice of *rutaceæ*.

ALLIED DRUGS.—As a matter of purely historical interest it may be mentioned that a quantity of the bark of *strychnos nux vomica* was imported from India eighty years ago, and sold as Angustura, causing some serious cases of poisoning and general alarm.

All bitter tonics with a trace of spiciness may be considered as allied drugs to Angustura. See Magnolia for example. *W. P. Bolles.*

ANIDROSIS is a functional disorder of the sweat-glands, consisting in a diminished and insufficient secretion of sweat. It is most apt to occur in connection with certain skin diseases, as ichthyosis, eczema, psoriasis, etc., also as a result of nerve injury, or of an emotional shock. It may result from a congenital deficiency in the sweat-glandular apparatus. Well-marked cases of apparently idiopathic anidrosis have been observed, where great distress has been caused by the inability to sweat in hot weather. The disease is a rare one, only five cases having been reported among nearly sixty thousand included in the statistics of the American Dermatological Association.

The *treatment* of the symptomatic varieties must begin by removal of the cause. Where the diminished perspiration does not seem dependent on any traceable cause every means should be used to excite the activity of the sweat-glands. Hot and steam baths, cold bathing, with frictions, exercise, and the employment of such drugs as pilocarpin, with general tonic treatment is to be resorted to. *Arthur Van Harlingen.*

ANILINE (*Amidobenzene, Phenylamine*, C_6H_7N). Aniline is an aromatic amine presenting itself as a thin, oily, colorless fluid of a vinous odor and hot, aromatic taste. It is very volatile and inflammable, dissolves very slightly only in cold water, but freely in alcohol, ether, fixed and volatile oils, etc. It is remarkable for the great number of colored crystallizable compounds that it forms with acids. Physiologically, aniline is a powerful neurotic of more interest toxicologically than therapeutically. Experiments upon animals show serious derangement of the functions of the spinal cord as the essential element of the aniline action. The aniline dye-stuffs are certainly, in the great majority of instances, not themselves poisonous, but in the form in which they are in some cases practically used they may poison, either because of the presence in them of uncombined aniline or of arsenic. Many of the cases of eczema following the wearing of aniline-dyed shirts or stockings have doubtless their cause in such contamination of the dye.

Therapeutically aniline has been experimented with, to a small extent, in some nerve diseases, notably chorea and epilepsy, and in scarlatinal dropsy. Aniline has been given in doses of a grain or two, and aniline sulphate in doses of five grains or more. *Edward Curtis.*

ANILINE, POISONING BY. Experiments on animals and occasional cases of poisoning in the human subject show that aniline and its salts are poisons. The external application of the hydrochlorate of aniline, for psoriasis, has been followed in two cases by symptoms of poisoning. In one case there was vomiting in one hour and a half, incontinence of urine, and cyanosis after four hours; a second application was followed by drowsiness, dyspnœa, and marked cyanosis. In the other case the solution applied was more dilute; there was insensibility and cyanosis after four hours. Both patients recovered (Lailler). Dr. Turnbull gave 1.94 Gm. (0.5 drachm) of the sulphate of aniline to a dog. In two hours and a half there was vomiting, followed an hour later by purging. The pulse was rapid, the breathing labored. There was paralysis of the hind legs. In five hours the symptoms abated and the animal recovered.

Although aniline is an active poison, whether taken in the liquid form or inhaled in the form of vapor, acute poisoning by it is rare. The cases thus far reported have occurred among workmen in aniline and aniline-color manufactories, and have been caused, for the most part, by breathing the vapors of aniline. The symptoms appear very quickly, sometimes immediately. There is giddiness and inability to stand. The skin is cold; the lips, face, mucous membrane of the nose, and the nails have a blue or purple color. The pulse and respiration are at first accelerated, later retarded. Sometimes there is vomiting. In fatal cases death is preceded by coma (Mackenzie and Letheby, Hirt, Knaggs, Häussermann and Schmidt).

Chronic poisoning has been frequently observed. It is characterized by: 1. Eruptions on the skin; these may be papular, vesicular, or pustular, and are found principally on the hands and feet; ulcerations about the scrotum have been observed. 2. Disturbances of the digestive organs; nausea, vomiting, and loss of appetite. 3. Disturbances of the nervous system; ringing in the ears, amblyopia, headache, muscular weakness, sometimes paralysis, especially of the extremities, usually accompanied by anæsthesia. Conjunctivitis, subacute blepharitis and habitual cough have been observed.

Treatment must be symptomatic. In cases of chronic poisoning the symptoms usually disappear when the patient is removed from his work. After death, aniline may be detected in nearly all the organs of the body. It is eliminated through the kidneys, and in part, probably, through the lungs. Authorities differ as to the physiological effect of the pure aniline colors. Feltz and Ritter state that fuchsin produces albuminuria in both man and animals. They administered it to dogs, and found albumen and granular and fatty casts in the urine. After death they found degeneration of the cortical portion of the kidneys. Other observers believe that fuchsin is perfectly harmless if pure, and that the above results were caused by arsenic, which is a frequent impurity in aniline colors. Aniline colors are sometimes used for coloring confectionery, wines, and syrups; but the amount required to produce the requisite tint is so small that it is doubtful if a sufficient quantity is taken, under ordinary circumstances, to produce any serious disturbance, provided always that the pigment be pure. The eruptions produced on the skin by articles of wearing apparel colored with aniline dyes are probably due in most cases to the action of arsenic. Sometimes, however, the fabric which has produced the eruption is found to be free from arsenic. In such cases it is uncertain whether the irritation is caused by the color itself or by free aniline, or by the mordant. *William B. Hills.*

ANISE. *Anisum*, U. S. Ph.; *Fructus Anisi*, Ph. G.; *Anis Vert* or *Anis*, Codex Med.

Pimpinella Anisum Linn.; Order, *Umbelliferæ*, the Anise Plant, is a small annual from thirty to fifty centimetres high (twelve to twenty inches). A native of the Orient, but so long under cultivation, that its wild form and original home are scarcely known. It has a slender, branched, smoothish stem, with variable leaves, the lowest being simple, the upper more or less compound. The flowers and fruit are small. It is a long-known drug, mentioned by the earliest writers on medicine, and referred to as a medicine or spice in nearly every period since then. It has been cultivated in the warmer parts of Europe, Asia Minor, Egypt, Russia, and Africa for centuries; more recently, also, in India and South America. The principal supply comes from Southern Europe.

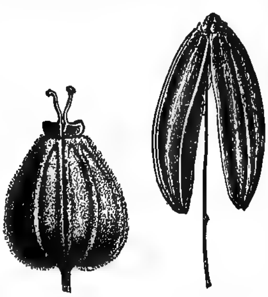

FIG. 174.—Anise, enlarged about six times.

The fruit, which is the officinal part, like those of the order in general, consists of two halves or carpels, rather loosely attached together. In many cases these fall apart upon ripening, but not in Anise, where they are always adherent. The whole fruit, so formed, is small, hard

ovoid, seed-like, and finely bristly-pubescent. It has a grayish-green color, and strong, agreeable odor. A transverse section is nearly circular in general outline, with ten projecting ribs. The *vittæ* are numerous, two or three times as many as the ribs, and are rather small. The seed on section is somewhat crescentic. Anise is apt to be pretty dusty, and is mixed with stems and various coarse impurities, requiring frequently to be winnowed or sifted, but it is not often adulterated. In one instance, many years ago, serious trouble was caused on account of its being mixed with Conium.

CONSTITUENTS.—Anise contains a total of from two and a half to three per cent. of essential oils, one liquid, and one a solid stearoptene, *Anethol.* This latter varies in amount from one to more than three-fourths of the whole. Both have the same composition and similar qualities. The officinal oil (*Oleum Anisi*, U. S. Ph.) is a mixture of both. It is a yellowish or white liquid, of fragrant and familiar odor, and sharp warm taste. Specific gravity about 0.98, increasing with age. In solubility oil of Anise resembles other essential oils; it is freely soluble in Alcohol, Ether, fats, etc., and only sparingly so in water, enough, however, to impart its odor and taste.

Anise is a mild aromatic, much used to diminish the griping tendency of cathartics, to relieve colics and flatulency, to stimulate digestion, and to flavor other medicines. It is also an ingredient of certain cordials. The *dose* of the whole or coarsely powdered fruit may be stated as from one to three or four grams (1–4 Gm. = gr. xv. ad ʒ j.), administered as a hot strained infusion; but the oil is a better form, *dose* one to three decigrams (0.1–0.3 Gm. = ♏iss. ad v.). The officinal preparations of the Oil are: Anise Water (*Aqua Anisi*, U. S. Ph.), a saturated solution may be used *ad libitum* as a vehicle; Spirit of Anise, "Essence of Anise" (*Spiritus Anisi*, U. S. Ph.), 1–10, the most eligible preparation. *Dose* from one to two and a half grams (1–2.5 Gm. = ♏xv. ad xl.). In Paregoric (*Tinctura Opii Camphorata*, U. S. Ph.) and in Liquorice and Opium Troches (*Trochisci Glycyrrhizæ et Opii*, U. S. Ph.) it is only added as a corrigent.

ALLIED PLANTS.—Of the sixty or seventy species of the genus named, several are or have been in use, but no others are of much importance. *Pimpinella Saxifraga* Linn., and *Pimpinella magna* Linn., yield *Burnet Root* (which see). The Order Umbelliferæ is an interesting one to the botanist, on account of the well-defined characters separating it from all the other natural orders, even from its nearest relatives, the *Araliaceæ;* and also on account of the remarkable family resemblance of the plants included in it, which serves to make their classification at once a difficult and a fascinating problem. The larger genera have been several times changed and made over, and are probably not yet in a permanent position. The flowers and habit are so similar that the classification depends principally upon characters obtained from the fruit. There are thirteen hundred species in the Order, distributed most abundantly over the temperate and colder countries of Europe and Asia, with, however, a good many in North America, and a few in other parts of the world. They are seldom tropical, almost always herbs, and have in general the habit so familiar in the Carrot, Parsnip, Water Hemlock, etc. The roots may be thin, but are often thick and fleshy, with milky or colored juice. The stems are branched, with prominent joints, frequently hollow. The leaves have sheathing bases and are generally compound. The flowers are in simple or oftener in compound *umbels*, which furnish the Order with its name. The flowers are pentamerous with a double, inferior ovary, composed of two scarcely united, one-seeded, indehiscent carpels, which usually fall apart in fruit. They always have five more or less marked ribs, upon the development of which, and upon the presence or absence of *vittæ* between which, the division into genera largely depends. The order furnishes many plants of interest or utility to man; some as agreeable condiments or salads, or even vegetables for boiling; some as useful medicines; and a few as dangerous and peculiar poisons. Its medical properties will be seen from the following synopsis: *Essential Oils* are formed in nearly every species, giving to each its peculiar flavor. These are almost as universal as in the *Labiatæ,* and constitute one of the characteristic qualities of the order. In most cases they are in the comparatively large tubular reservoirs, called *vittæ*, which lie between the ridges of the fruits; but they also occur in other parts of the plant, especially in the leaves and roots. Occasionally the *vittæ* are absent. Rarely there is no essential oil. The natural oils are usually mixtures of the hydrocarbons of the $C_{10}H_{16}$ type and stearoptenes. They have, for the most part, an agreeable odor; they are not poisonous, but usually mildly stomachic. As their medicinal value is about equal, the selection of one or another is largely a matter of taste. The Oil of Assafœtida is an exception in composition and odor. Many Umbelliferæ contain also *Resins.* These are sometimes suspended in an abundant milky or colored latex which flows freely from slight wounds, and hardens in drops or masses, as in the case of Assafœtida and Ammoniac; or they may remain and be dried in the roots themselves as in Sumbul; in the former case they are associated with gum which holds them in suspension in water, in both cases with a varying quantity of oil. This group of constituents is stimulant and antispasmodic in its medicinal action.

The third group is less natural and uniform than the other two. The first and most important instances are volatile and highly poisonous *alkaloids*, of which *Conine* is an example. Allied to these in action are some poisonous *neutral* or *acid* substances—*e.g.*, *Cicutin*—besides which are a number of vague, bitter, and disagreeable, but not always deleterious constituents, such as "*Vellarin*," etc.

The above qualities, it should be understood, are not divided singly among the different plants of the order, but occur often together in the same plant. The oils, especially, are so rarely absent, that they are almost always to be found with the others. But in the cases of the more valuable ones, some one or another quality is sufficiently prominent to make a classification, upon a chemicotherapeutic basis, possible and instructive.

The following arrangement is based on the foregoing discussion, and is not the usual botanical sequence:—that is also given further on.

First Group.—Yielding agreeable, or not offensive, oils from their fruits (which are mostly the parts used); stems and roots sometimes eaten, often fragrant and slightly resinous. Generally European species growing in open dry places, long cultivated, and not poisonous. The most typical examples are highest on the list.

Name.	*Constituents (oils and stearoptenes).*
Anise	Fluid and solid Anethol.
Fennel	Hydrocarbon and Anethol.
Caraway	Hydrocarbon (Carvene) and Carvol (liquid).
Ajowan	Hydrocarbon and Thymol (cryst.).
Coriander	Two oils, probably hydrates of $C_{10}H_{16}$.
Cumin	Two oils, "Cymol" and "Cuminol."
Dill	Anethene and Carvol.
Parsnip	Essential oil and miscellaneous substances.
Celery	Essential oil and Apiin (an inert glucoside).
Parsley	Oil and cryst. Stearoptene, Apiin, and "Apiol" (a mixed substance).
Imperatoria	Oils—Peucedanin.
Carrot	Oil, coloring matter (Carotin).
Angelica	Oil, Angelic Acid, Resin (has colored juice).
Lovage	Oil, Resin (has colored juice).
	Etc., etc.

Second Group.—Large Persian or African plants, with milky juice, yielding gum resins from their stems and roots, usually offensive.

Name.	*Constituents.*
Assafœtida	Resin, gum, sulphuretted oil.
Sumbul	Resin, bluish oil.
Galbanum	Resin, gum, oil.
Ammoniac	Resin, gum, oil.
Thapsia (European)	Irritating resin and oil.
	Etc. (See Assafœtida.)

Third Group.—Plants containing poisonous, bitter, or nauseous principles, sometimes alkaloids of the Conine type, not usually very fragrant, sometimes without *vittæ.*

Name.	*Constituents.*
Conium (Hemlock)	Alkaloids, Conine, Conhydrine.
Cicuta	Cicutoxin, neutral (?) poisonous.
Hydrocotyle	"Vellarin," qualities indefinite.

Besides these various species of *Œnanthe Phellandrium, Sium* and others have more or less deleterious qualities.

The natural arrangement of the above, from Bentham & Hooker's "Gen. Plantarum," is as follows:

(The botanical names of the plants are also given.)

Hydrocotyle asiatica, Linn	Hydrocotyle.
Conium maculatum, Linn	Hemlock.
Apium graveolens, Linn	Celery.
Apium Petroselinum, Linn	Parsley.
Cicuta virosa, Linn., maculata, etc	Cicuta.
Carum carvi, Linn	Caraway.
Carum Ajowan, Benth. & Hook	Ajowan.
Pimpinella Anisum, Linn	Anise.
Fœniculum vulgare, Gaertin	Fennel
Ligusticum Levisticum, Linn	Lovage.
Archangelica officinalis, Hoffin	Angelica.
Ferula Narthex, Boiss, etc	Asafœtida.
Ferula galbaniflua, Boiss & Buhse, etc	Galbanum.
Ferula Sumbul, Hooker fils	Sumbul.
Dorema Ammoniacum, Don	Ammoniacum.
Peucedanum graveolens, Hiern	Dill.
Peucedanum sativum	Parsnip.
Coriandrum sativum, Linn	Coriander.
Cuminum Cyminum, Linn	Cumin.
Daucus Carota, Linn	Carrot.
Thapsia garganica, Linn	Thapsia.

ALLIED DRUGS.—Besides the *Umbelliferæ* above, the *Labiatæ* are very similar, chemically and medically to Anise and the aromatic Umbellifers (see PEPPERMINT). The domestic spices and their congeners are also more or less adapted to the same uses (see CINNAMON); but the most exact duplicate, so far as their oils are concerned, is the subject of the next article (STAR ANISE).

W. P. Bolles.

ANISE, STAR. *Illicium*, U. S.; *Anis étoile, Badiane*, Codex Med. The fruit of *Illicium Anisatum* Loureiro. Order, *Magnoliaceæ*.

This is a small tree, from five to ten metres (fifteen to thirty feet) in height. It has a dark stem, smooth, dark-

FIG. 175.

FIG. 177.

FIG. 176.

FIG. 178.

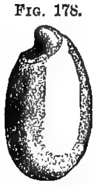

FIG. 179.

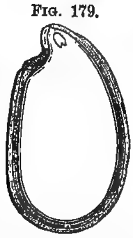

FIG. 175.—Illicium Anisatum, Flower (Baillon). FIGS. 176 and 177.—Gynæcium and Fruit of Illicium Anisatum (Baillon). FIGS. 178 and 179.—Seed of the Illicium Anisatum, entire and in longitudinal section (Baillon).

green, leathery, dotted and fragrant leaves, and regular axillary flowers, two or three centimetres in diameter (about one inch). The perianth, like that of the Magnolias, is in several series of threes. The stamens are numerous. The "gynæcium," however, consists of only about eight carpels in a single series, and ripens into a star-shaped fruit, about as large as the flower.

The Star Anise tree is a native of China, where it has been cultivated for hundreds of years. It is also grown in Japan and other places for ornament, but the supply of fruits comes exclusively from the first-named country. The fruit consists of the eight carpels, united to a short central prolongation of the receptacle, from which they can be easily separated, but distinct from each other. Each carpel is short, laterally compressed, "boat-shaped," pointed at the upper and outer extremity, and dehiscent at the upper and inner border. The pericarp is deep brown, rather woody, brittle, fragrant, and spicy. The seeds, which can be seen through the split in the carpel, although this is not usually wide enough to let them fall out, are also brown, but very smooth and shining. They are less fragrant than the carpels, but contain considerable fixed oil in their kernels. Both testa and pericarp show, under the microscope, numerous oil-cells, and the parenchyma of the seeds reveals drops of fat.

COMPOSITION.—Besides sugar, gum, and oil, which, although abundant, have no practical value, Star Anise is remarkable for containing a large percentage (from three to five) of an essential oil, so similar in odor, taste, properties, and composition, to that of Anise, that no means can be relied upon to distinguish them from each other. Oil of Illicium is said not to congeal so readily as that of Anise. Illicium is never prescribed, and is only acknowledged by the Pharmacopœia as a commercial source of "Oil of Anise," which is "a volatile oil distilled from Anise, or from Illicium" (U. S. Ph.).

ALLIED PLANTS.—The small genus Illicium, of only five species, is separated from Magnolia principally by the simplicity of its fruit. It is, in general, a more aromatic genus than the other. *I. religiosum* Sieb., according to Baillon only a variety of *I. anisatum*, cultivated in Japan and India, produces poisonous fruits closely resembling those of Chinese *Illicium*, but containing in addition to the oil, which is more clove-like in odor, and also suspicious, a neutral poisonous principle, *Sikimin*. The American species yield fruits similar to Star Anise, but inferior in quality. They are not in the market. (For Order, see MAGNOLIA.)

ALLIED DRUGS.—See ANISE. *W. P. Bolles.*

ANKLE-JOINT. As this joint supports the weight of the body considerable stability is required of it. This is secured mainly by the shape of the articular surfaces, which interlock like a mortise and tenon. The tibia and fibula, strongly united by ligaments (interosseous and inferior tibio-fibular, Figs. 180, 181, and 182), form the mor-

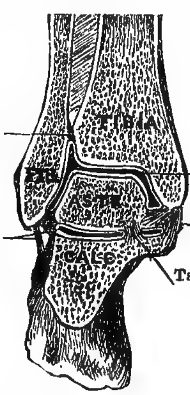

FIG. 180.—Frontal Section of Right Ankle.

tise by embracing with their extremities (malleoli) the tenon-like astragalus. The joint is a hinge, its movement angular, and in a single oblique plane (corresponding to the outward pointing of the toes) through an arc of some eighty degrees. In the fœtus of six weeks (Henke and Reyher) the joint is arranged like that of some marsupials, so as to admit of rotation, the astragalus sending a process up between the tibia and fibula. A trace of this movement remains in the adult. To guard against the thrust of the

tibia and fibula when alighting on the extended toes (the commonest form of dislocation arises thus), the astragalus is narrower behind than in front, and a slight lateral move-

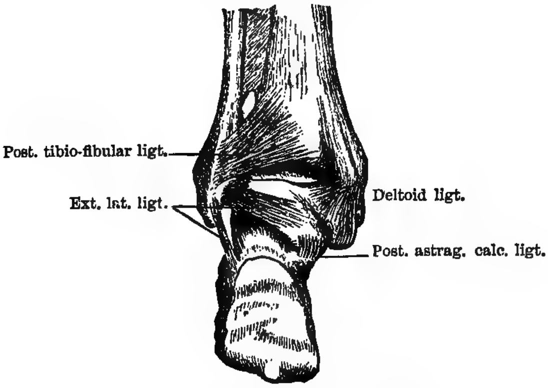

FIG. 181.—Rear View of Left Ankle.

ment is therefore possible when the malleoli are thrown back in complete extension. The malleoli are held against the articular surfaces in all positions by the elasticity of the

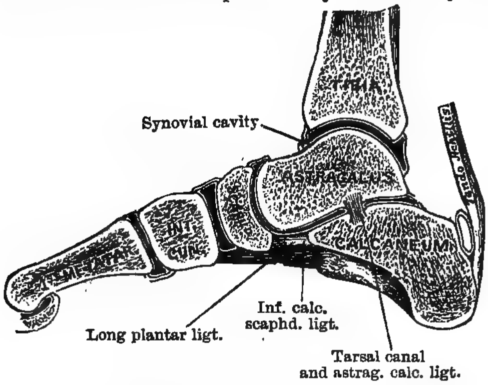

FIG. 182.—Sagittal Section of Right Ankle.

shaft of the fibula, which bends inward when the wedge pushes the malleoli apart, springing back during extension. The axis of rotation of the curved superior surface of the astragalus (Fig. 182) passes through the most fixed part of the bone, viz., the tarsal canal, touching the outer malleolus but passing below the inner, which does not descend so low (Figs. 180 and 181). The original capsular ligament (see Arthrology) remains in front and behind as a thin layer of fibres connected with the synovial membrane and strengthened by the extensor tendons in front and the tendon of the flexor longus pollicis behind. Effusion into the joint usually shows first in front. On the sides strong bands are developed. The internal lateral ligament (Figs. 180, 181, and 183), also called the deltoid, is the strongest of these; in dislocations usually tearing the bone apart. It is a thick, triangular bundle, ensheathing the internal malleolus and passing to the calcaneum, the scaphoid,

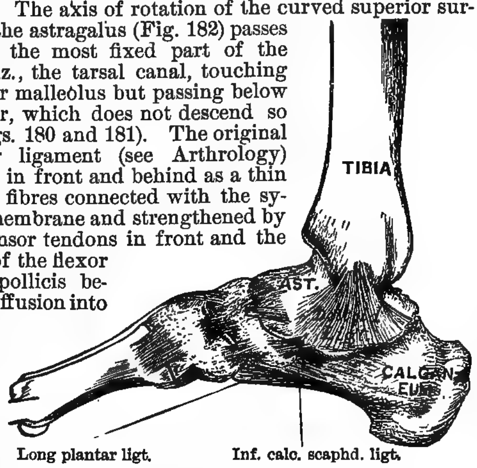

FIG. 183.—Inner Side of Right Ankle.

and the calcaneo-scaphoid ligament. The tendon of the tibialis posticus strengthens it. Deeper fibres pass to the astragalus. In amputating at the ankle the joint is opened on the inner side, because of the shortness of the malleolus, and the existence of this deep band should be remembered. The external lateral ligament (Figs. 180, 181, and 184) is composed of three bands which radiate from the lower part of the malleolus, the anterior and posterior bands passing to the astragalus, the middle one to the calcaneum. The synovial cavity is quite extensive, communicating above with the inferior tibio-fibular articula-

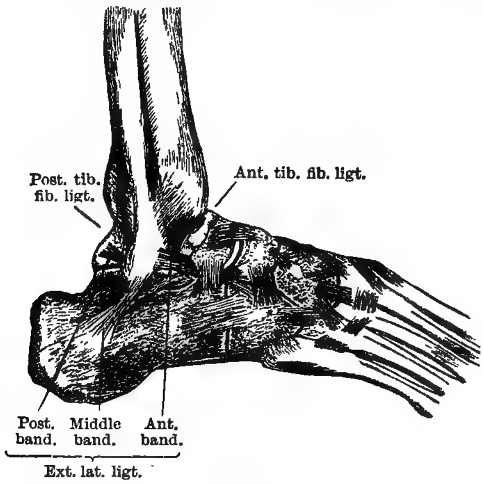

FIG. 184.—Outer Side of Right Ankle.

tion. Its capacity is not affected by the position of the foot, and no change of posture takes place during inflammation of its membrane.

Sensations of pain are sometimes felt in the ankle without lesion of the joint, caused by some injury to the long nervous trunks which supply it, viz., the long saphenous, connected with the lumbar plexus, and the anterior tibial with the sacral plexus. The vascular supply arising from twigs from the anterior and posterior tibial arteries, and discharging by both saphenous veins, may be interfered with by tight boot-laces and occasion a dull pain.

Frank Baker.

ANNATTO (*Orleana*). This coloring matter is obtained from the pulp of the fruit of *Bixa Orellana* Linn., a small tree of South America, belonging to the order Bixaceæ. The plant is also cultivated in all tropical countries. Commercial annatto is prepared in a variety of ways, having for their object the separation from the pulp of its coloring matter, and its preservation in a moist or dry condition. The bruised fruit is sometimes washed over a sieve and the liquid allowed to stand until the annatto subsides; or it is separated by fermentation. The product is a brownish-red, resinous substance, usually in moist masses, but sometimes in dry, brittle cakes. It has often little or none, sometimes a sweetish, resinous odor, and a saltish-bitter taste. Some lots have a very disagreeable smell, and are said by Hager to be prepared with urine. Two kinds are said to be imported from French Guiana, one without unpleasant smell, the other disagreeable. A third variety comes also from Brazil, but this is not so highly esteemed as the best French.

Annatto is a mixed substance, nearly insoluble in water, soluble in Alcohol, Ether, Fatty, and Essential Oils, making orange-red solutions. It consists principally of a yellow (*Orellin*) and a red (*Bixin*) resinous coloring matter.

The principal demand for Annatto is for dyeing fabrics, but it is also extensively employed to color butter and cheese. Internally given, it is said to be "tonic and antidysenteric."

ALLIED PLANTS.—*Bixaceæ* is a rather small, exclu-

sively tropical order, which, besides Annatto and Chaulmugra seeds, furnishes scarcely anything of economic interest. (See Chaulmugra.)

ALLIED DRUGS.—For a list of "pharmaceutical" dyes, see Saffron.

W. P. Bolles.

ANODYNES. This term (α, privative, and ὀδύνη, pain) is applied synonymously with *analgesics* (α, and ἄλγησις) to a small class of drugs whose peculiar action is to relieve pain. The anæsthetics, which also relieve pain, but by suspending all sensation, together with consciousness and motility, are not anodynes.

By far the most important member of this group is opium. (For detailed account of the action of this drug, see Opium.) Though other remedies occasionally relieve the milder degrees of pain, opium alone can be relied upon to remove severe suffering. It has its limitations, in occasional paroxysms of agony such as attend the passage of renal and gall-stones, when nothing short of absolute anæsthesia will bring relief. Here opium, in doses so high as even to endanger the life of the individual, is without effect on the pain. In the ordinary forms of severe pain a failure of opium to give relief is almost always due to improper adjustment of the dose. Of course, the subsequent ill effects of opium, such as nausea, constipation, and narcotic addiction may be so marked as to form a contra-indication, more or less strong, to its use. But the point here emphasized is that, as an anodyne pure and simple, opium, if properly administered, is almost always successful. In certain subjects, particularly women and nervous persons, the intoxicating effect of opium predominates in the moderate doses. In such cases the dose must be cautiously increased beyond the limits usually prescribed, or else the opium must be combined with some nervous sedative, as bromide of potassium or chloral. For it should be remembered that opium is, in analgesic doses, by no means always a hypnotic. In many cases where it completely removes pain, the patient does not close his eyes in sleep the whole night.

The common cause of failure in securing the analgesic effect of opium is conformity with a strict and arbitrary posological standard, and forgetfulness of the fact that there is much difference in the capacity of different individuals, and of the same individual at different times, for the drug. Under the influence of severe pain, the toleration for opium increases enormously. In general and pelvic peritoneal inflammations, for instance, it may be necessary, in order to get the full effect of opium, to administer it in doses up to four grains (or its equivalent in morphia) at a time, and repeat with sufficient frequency to keep the patient just short of narcotism. This bold use of opium in pelvic inflammation has come into practice of late years, and some of the figures published of the amounts actually administered are very large. They are not given here, however, for the reason that no definite figures reported in one case should have any weight in determining the amount to be given in another case. It is needless to say, with a patient suffering from a frank peritonitis, where these heroic doses have been made necessary, and when the individual is held just on the verge of narcotism, with respirations perhaps lowered to ten or twelve per minute, that no standing order should be given in advance for a stated administration of the drug, and that each dose should be given by the practitioner himself, who should on no account leave the case, and who should have at hand atropia and a faradic battery ready for instant use in case the narcotism should go too far.

Among the derivatives of opium, morphia, as an anodyne, stands *facile princeps.* Its convulsant, constipative, and diaphoretic action are all less than of opium, while as an analgesic it is even more active than the drug from which it is derived. Of the other principal alkaloids, the analgesic effect upon man is in the following order: Narceine, Thebaïne, Papaverine, and Codeine. The interval between the strongest of these and morphia is, however, great, one authority claiming that narceine is four times weaker than morphia, and in practice it is found that none of them can be relied upon with certainty in pain of a severe character. The promptness and effectiveness of morphia as an anodyne are usually enhanced by the hypodermic method of administration.

Chloroform is at times an anodyne. This is especially the case when injected subcutaneously in the vicinity of a nerve, as in sciatica and other forms of neuralgia. Administered by the mouth it also has a local analgesic effect, due partly, no doubt, to its revulsive counter-irritant action. It is thus of use in gastralgia and flatulent colic.

Belladonna may be considered a feeble anodyne. Administered with opium it has not only a corrigent effect, mitigating some of the unpleasant symptoms of the latter drug, but is also apparently, to a certain extent, an adjuvant.

Cannabis Indica is a still weaker anodyne, if it deserves the name at all. Its hypnotic action can overcome a moderate degree of discomfort, but not much actual pain. It is of some repute in the treatment of chronic migraine.

Charles F. Withington.

ANOSMIA (α, privative, and οσμη, odor; literally, odorless), now commonly, but erroneously, accepted to denote "loss of the sense of smell."

It is due either to disease or injury of the olfactory nerves or lobes, or of their cerebral centres, or to conditions of the nasal cavity which interfere with the proper function of the olfactory nerve. Among the causes of anosmia from central lesion are: Separation of the olfactory bulbs from the brain by concussion, as from a blow upon the head, preferably upon the occiput; degenerations of the nerve; tumors, abscesses, or hæmorrhages, either in the substance of the brain or at its base. A moist and normal condition of the nasal mucous membrane being required for a perfect sense of smell, it follows that any process may cause anosmia which prevents the terminal nerve-filaments or olfactory cells from receiving the stimulus necessary for their excitation. Hence, in the early stage of acute catarrh, in atrophic rhinitis, and in syphilitic disease, which conditions are attended with undue dryness; in tumors of the nostril, and in some cases of hypertrophic catarrh in which the odoriferous particles are mechanically prevented from reaching the olfactory region, loss of smell is apt to result. Long-continued paralysis of the fifth and seventh nerves may cause anosmia; in the former case by the resulting interference with the nutrition of the nasal mucous membrane, and in the latter, because the patient may be unable to sniff the odorous particles, and because, the orbicularis muscle being paralyzed, the tears flow over the cheek instead of passing through the lachrymal duct to furnish necessary moisture to the nasal mucous membrane.

The presence of pigment in immediate proximity with the terminal olfactory nerve-cells, seems necessary for the proper development of the olfactory sense. Deficiency of this sense has been observed in albinos and in white animals, while in animals in which the sense of smell is most acute the olfactory region is darkest.

The sense of taste is constituted by the recognition of but four principles, namely, bitter, sweet, salt, and acid. The perception of other flavors depends, therefore, upon the olfactory sense, and when the latter is lost the former is also destroyed. Anosmia may be congenital, either from deficiency or malformation of the nervous apparatus, or from abnormal conditions of the mucous membrane. It may also occur with the general decline incident to old age.

DIAGNOSIS.—Mechanical obstruction will be recognized by anterior rhinoscopy, while in cases of neurotic origin the associated symptoms will suggest the real cause. In testing a patient it should be learned whether the trouble is bilateral or unilateral. Test odors familiar to the patient should be used, but their nature should, of course, be concealed from him. Essential oils, such as of cloves, cinnamon, or rose, will be found convenient. It should be remembered that alcoholic preparations, such as eau de cologne; vapors, as of ammonia; snuff, etc., are not suitable as tests, since their action is irritant and does not necessarily affect the nerve of special sense.

TREATMENT.—If the anosmia be due simply to insufficiency of nerve action, possible relief may be afforded For this Althaus has recommended the insufflation of sulphate of strychnia, about one-thirtieth of a grain, in combination with any convenient inert vehicle, such as starch, gum acacia, or sugar of milk two or three times a day, the quantity of strychnia to be increased to double the above amount if no effect be produced. Galvanism has proved unsuccessful in the hands of the great majority who have employed it, although some have claimed success from its use. The writer believes that he has seen temporary improvement from the application of a mild Faradic current. The use of electricity in these cases has never been satisfactorily studied, however, and it is to be hoped that future investigation will lead to more favorable results. Anosmia depending upon catarrh will be likely to improve if the catarrhal condition be recent and remediable, otherwise not. When it is due to mechanical obstruction, as in the case of polypi or excessive turbinated hypertrophy, removal of the obstruction will usually be followed by restoration of the normal function.

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D. Bryson Delavan.

ANTACIDS. These are agents employed to correct acidity of the primæ viæ or of the urinary secretion. For the former purpose the most commonly used remedies are potassa, soda, lime, magnesia, and their carbonates. Potassa or soda may be used when the bowels are regular in their action, and when it is simply desired to neutralize an excess of acid in the stomach. When constipation exists, magnesia is selected by preference, and when diarrhœa is present lime-water or chalk mixture should be employed. The acetate and citrate of potassa are the salts usually exhibited to render the urine neutral or alkaline. (See Art. Alkalies.) *T. L. S.*

ANTHELMINTICS. (Synon., Antiscolics, Vermicides, Vermifuges.) Remedies used to destroy, or cause the expulsion of, intestinal worms. The term vermicide is used to designate those agents which kill the parasites, while vermifuges simply dislodge them and expel them from the bowel Since there are three sorts of intestinal worms, it will be more convenient to consider the remedies suitable for each variety separately, for not all the anthelmintics are equally fatal to every kind of entozoa.

Remedies Employed in the Treatment of Tape-worm, or Tænia.—The principal drugs of this class are male fern, pumpkin seed, kameela, kousso, pomegranate bark, turpentine, areca, and chloroform. Male fern is, perhaps, the most frequently employed of these remedies, and is certainly very efficient, especially against the bothriocephalus latus. It is best given in combination with turpentine. Chloroform is a very certain anthelmintic, and many cases of success have been reported from its use, but it is a dangerous remedy and should never be selected by preference when there are other more safe drugs at hand. Kousso is seldom employed at the present day. Pomegranate bark sometimes serves a very good purpose. It is often given in the form of the sulphate of its alkaloid, pelletierine. Kameela is employed for the destruction of both the tape-worm and round-worms. It is likewise fatal to thread- or seat-worms. The drug to be preferred when the expulsion of tænia is desired is certainly pumpkin seed (pepo). It is very destructive to this worm and is, at the same time, without danger to the bearer of the parasite.

Remedies Employed in the Treatment of Round-worms, or Lumbrici.—These are santonin, calomel, mucuna, azedarach, spigelia, chenopodium, and tin. Santonin is the most commonly employed anthelmintic of this class, but a safer, and in most cases equally efficacious, drug is spigelia, or pink root. The latter is best given combined with senna or some other cathartic. Chenopodium, or wormseed, and azedarach (employed chiefly in the Southern United States) are useful, but inferior to the before-mentioned remedies. Calomel, when given in sufficient dose, is often sufficient to cause the expulsion of lumbrici, but is usually exhibited in combination with santonin. Mucuna and tin (pulvis stanni) are so-called mechanical anthelmintics, the former being supposed to kill the parasites by transfixing them with its hairs. These agents are seldom employed.

In administering anthelmintics in the treatment of either round or tape-worms, certain precautions are to be observed. They should always be given when the stomach, and as far as possible also the intestines, are empty. Thus their exhibition should be preceded by a fast, if possible, for twenty-four hours. When for any reason this cannot be accomplished, the remedy should be given in the morning before breakfast, a light supper only having been taken the evening before. It is usually advisable to give the drug employed in combination with a cathartic, calomel, senna, or turpentine, and its administration should be followed in a few hours by a dose of castor oil or some other smart purge.

Remedies Employed in the Treatment of Thread-worms, or Vermiculares.—Many of the drugs above mentioned as efficacious in causing the expulsion of lumbrici are equally fatal to thread-worms, but are seldom employed for this purpose. Vermiculares being seated in the lower bowel are usually easily reached by enemata, and should always be so treated. The substances most frequently used for this purpose are lime-water, infusion of quassia, carbolic acid, and salt. Quassia infusion is probably the best, and seldom, indeed, fails to dislodge the parasite. Carbolic-acid solution is very effective, but its employment is not unattended with danger, and, if used, it should be injected in very weak solution. It may advantageously be employed to bathe the parts externally at the same time that lime-water or infusion of quassia is thrown into the bowel. In the absence of other remedies an enema of simple salt and water will be found to answer an excellent purpose. *Thomas L. Stedman.*

ANTHRAX. Carbunculus contagiosus, Milzbrand, Charbon, Malignant Pustule. (See also Carbuncle, and Furuncle.)

An acute intoxication of a part of the body, or of the entire body, dependent upon the entrance of a schizomycete (Bacillus anthracis), and its multiplication in the animal system. The disease is primary in animals, and occurs in the human subject in two distinct forms, viz., directly, by inoculation, or indirectly, by eating the flesh of animals infected with anthrax. The blood and tissues of an animal dead from anthrax are found to contain a minute organism, in the form of a rod bacillus. This organism, when placed in appropriate culture-fluids, begins to increase in length within two hours, and in three hours will have become elongated to twenty or thirty times its original length. Soon, long, wavy threads are formed, in which a granular content is visible after an interval of ten to fifteen hours. Within these threads granules of sharply defined outline appear, which become free by rupture of the threads, and again form the original bacilli by becoming oval and afterward taking the rod shape of the original organism. After a few hours motionless rods are formed from these spores, and soon the elongated threads may be reproduced. The inoculation of these organisms produces the same fatal effect on animals as does that of blood taken from a diseased animal, but if the blood of the latter is filtered, so as to remove all germs, it is no longer infectious to a healthy animal (Klebs, Pasteur).

Study of anthrax and its bacillus makes it probable that the disease cannot originate *de novo*, but is always communicated by some medium capable of conveying the infection, and that it is always transmitted directly or indirectly from pre-existing cases.

The disease in man is always acquired from infected animals, or from the products of such animals. The

affection is principally confined to certain districts in the countries in which it prevails. It is generally restricted to damp, heavy soils, and in this respect it resembles intermittent fever.

Any part or tissue of an animal dead from anthrax is capable of communicating the disease; as blood, hair, skin, bristles, wool, claws, horns, flesh, bones, milk, mucus, fæces, etc. The contagion also clings to any substance which has been in contact with the disease, such as harnesses, halters, straw, hay, stalls, etc., and the disease is communicated by means of plants growing in soil in which the body of a diseased animal has been buried. It is also carried by the clothes or persons of stablemen and ostlers, and by the feet and proboscis of flies which have alighted upon the diseased animal (Davaine), and Bollinger found the same forms of bacteria in the stomach of a horse-fly which had previously alighted upon the body of an animal dead from anthrax. Upon inoculating a rabbit with the contents of the stomach, splenic fever was promptly developed.

Anthrax is more common in warm weather, reaching its greatest virulence in August and September. Contagion by means of the atmosphere is not proved. Putrefaction entirely destroys the activity of the anthrax virus (Bollinger). The disease has also been banished from places formerly the seat of infection by draining and cultivating the land. Colin found that a boiling temperature (100 C.), and the action of the gastric juice each destroyed the contagium, and thus it is less frequent from the use of milk and flesh from diseased animals.

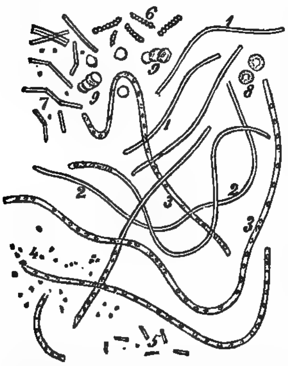

FIG. 185.—1, Growth of bacillus anthracis in one hour, showing an increase in length of twenty to thirty times the breadth of the organism; 2, long wavy threads from prolonged culture; 3, appearance of granular bodies of high refractive power in the bacillary threads, the spores of anthrax; 4, these bodies are liberated by rupture or dissolution of the threads, and become the bacillæ of anthrax by assuming the form of, 5, rods, and later, 7, of chains; when oxygen is exhausted, the growth of the bacillus ceases, and it assumes the form 6, of a string of beads; these spores, if introduced into the system, produce the rods, threads, and other forms of the organism of anthrax; 8, colorless, and, 9, red blood corpuscles. (After Zuel-

The greatest source of danger in this disease lies in the fact that the virus may be introduced through the smallest abrasion or injury of the skin, or of the mucous membrane of the alimentary canal. The degree of susceptibility of different animals to the poison of anthrax is not uniform. The herbivora are especially susceptible (experimentally, rabbits and guinea-pigs), the omnivora are less liable to take the disease (pigs, men, etc.), and the carnivora are least susceptible to the virus. Strong, healthy animals are more easily affected than the lean or sickly. One attack affords no protection against a recurrence of the disease. To show the ravages of this disease, it may be stated that in Russia, in the year 1864, no less than 72,000 horses were destroyed by it. In the province of Novgorod, within four years, more than 56,000 horses, cows, and sheep, as well as 525 men fell victims to this terrible scourge (see Bollinger). The disease spreads among men in proportion as they are exposed to infection from diseased animals or men. Shepherds, farmers, butchers, coachmen, stablemen, as well as veterinary surgeons and those individuals who handle animal products, such as wool-sorters, curriers, mattress-makers, etc., are especially exposed. Horse-hair is particularly dangerous. Further, articles like hides, etc., which may be transported great distances, are liable to give rise to the disease among those employed in their manufacture. Trousseau mentions two factories in Paris, in which horse-hair from Buenos Ayres was used in upholstering furniture, and in which not more than six or eight workmen were employed: during ten years twenty laborers died in these establishments from anthrax. Even after the hair has been long in use, the disease may be induced in the form of true malignant pustule in those employed in renovating the upholstering. A small scratch or crack in the skin or mucous membrane is sufficient for inoculation, and frequently it is caused by the unclean nails or fingers of workmen in scratching the face or arms. The disease may be spread from man to man. The discharge from the pustule (anthrax carbuncle) seems especially poisonous. Repeated transmissions of virus do not cause a diminution of virulence: the last generation is as highly infectious as the first. Anthrax is observed in men in the proportion of fifty-nine per cent., to forty-one per cent. in women. The seat of the primary sore, the malignant pustule, was found by Virchow to be confined to the face, hands, fingers, forearm, or neck in eighty-four per cent. of cases. In the rest, sixteen per cent., the arms and lower extremities were the seat of infection, and in these cases the patients were chiefly women and children, in whom these regions are less exposed than in men.

INTESTINAL ANTHRAX (MYCOSIS INTESTINALIS).—In some cases the primary lesion of anthrax, the malignant pustule, is seated upon the internal surface of the bowel, and produces the symptoms known as those of mycosis intestinalis, followed by the same train of fatal results as when the primary lesion is external. Often the milk and the flesh of diseased animals is taken as food, and doubtless the infection occurs from this source. The course and symptoms are not well understood. Often the workmen engaged in slaughtering diseased animals become infected by direct inoculation, while those eating the flesh of the same animals experience no harm. It is probable that the bacilli are destroyed by gastric digestion, but if they succeed in passing the stomach, they may then become seated in the mucous membrane of the bowel and there produce the disease.

PATHOLOGY.—The pathology of malignant pustule consists of the series of changes which follow inoculation with anthrax through either the skin or the alimentary canal. These changes are somewhat different, according to the particular circumstances of the individual case. When the virus is introduced through a scratch or abrasion of the skin, the period of incubation, or the space of time before the local symptoms of anthrax appear, may vary from a few hours to three days; in rare cases somewhat longer than this time may elapse. The course of the disease may be divided into three stages. The first or prodromal stage is that of incubation (period of latency). During this period the patient presents no marked symptoms of any serious disturbance. There is localized burning and itching at the seat of infection, which is generally thought to be due to the bite of an insect, such as a flea, which the spot closely resembles. After a period of incubation lasting from a few hours to three days (rarely longer) the local symptoms suddenly change. The second stage, that of eruption, now ensues, in which a small papule is seen at the seat of the previous irritation. This rapidly increases in height and in circumference, and generally presents a spot of dark discoloration at its summit. The itching and burning increase, and within a few hours a vesicle appears at the seat of discoloration in the papule. The vesicle now rests upon an indurated base, and contains a small amount of a serous, frequently bloody fluid. The surrounding skin swells so as to form a slight elevation around the papule, which now exhibits the peculiar appearances to which it owes its name of "malignant pustule," although this is not an accurate definition of the pathological condition at the seat of the local disease. The vesicle soon ruptures spontaneously, or is ruptured by the scratching of the patient, and reveals a dark-red base, which quickly dries, forming a livid or brownish crust. This is the commencement of the central gangrene or necrosis of tissue commonly observed in the carbuncle of anthrax. The crust becomes gradually larger, until it sometimes reaches a diameter of one to two centimetres, and the swelling and tension of the surrounding skin becomes more exten-

sive. A line of new-formed vesicles becomes developed around the margin of the crust, which contain a yellowish or brown fluid content.

The crust now gradually becomes free from pain and tenderness, and a doughy or boggy infiltration is felt for some distance in the tissues around the primary sore. The local condition, however, has no diagnostic value as an indication of the infection of the general system. In rare instances the local symptoms become less serious, the swelling subsides, the slough separates and is thrown off, and the ulcer heals by granulation. In such cases the chief danger is from septicæmia arising from the absorption of gangrenous matter. When general infection occurs the swelling increases and becomes doughy, the lymph channels are detected as reddened lines of induration, the glands become swollen, burning heat is felt in the part, which gradually becomes very painful, and later is the seat of a feeling of stiffness and numbness. The veins are often seen as dark-colored channels, and are sometimes plugged by thrombosis.

The foregoing appearances are caused by the local multiplication of the bacilli of anthrax in the part which is the seat of the primary infection. On the second or third day the germs may be found in the central part of the carbuncle, and in scattered groups in the rete Malpighii. At times large interwoven masses of germs are found in the tissues at this early period, and may be observed to spread into the neighboring parts by extending beneath the epidermis. In a carbuncle extirpated by Bardeleben on the twelfth day, which measured five centimetres in diameter, the bacilli were present in such enormous numbers that the tissues were everywhere crowded with them; they even filled the spaces between neighboring cells and obscured the normal structures of the part. In a carbuncle examined by Wagner the bacilli were so abundant as to hide the normal tissues. The centre of the pustule is generally the seat of hæmorrhage, and the effused blood is prone to undergo putrefactive changes. This accident is also frequently observed in the œdematous tissue immediately surrounding the pustule. From this centre general infection of the body (third stage) may now quickly take place, some cases requiring but a few hours (*cas foudroyants*), while others occupy from three to four, sometimes eight to ten, days for general poisoning of the system.

A second form of the disease is the "œdema carbunculosum seu malignum," "Milzbrandœdem." This is observed in cases in which inoculation occurs in parts covered with thin delicate skin, such as the eyelids, axilla, and occasionally the extremities. In these cases the local sore, the pustule, is not formed, there is no crust, no central gangrene, nor an eruption of vesicles, but a rosy, bluish, or even livid swelling appears at the seat of primary infection, and rapidly spreads in all directions. Generally the spot where the inoculation occurred may be seen as a dark point more or less elevated above the surface, but sometimes there is no visible point of origin. The swelling is frequently enormous, so that the arm may be three or four times its normal size, or the eyes may be entirely closed by large effusions of translucent fluid in the tissues. Like the previously described local manifestations of anthrax, this malignant œdema may subside spontaneously without causing destruction of the tissues, and the part may be restored to its former condition. There is generally abundant desquamation of epidermis after the disappearance of the œdema. At times the swelling is so enormous that the skin becomes gangrenous to a greater or less extent, and often vesicles or blebs are formed in the œdematous area which are filled with a bloody serum, and at the base of which is generally found a slough comprising the entire thickness of the skin. When the neck or eyelids are the seat of extensive œdema and sloughing, the loss of tissue may be so great as to lay bare the great vessels or other important structures, and death may ensue from hæmorrhage or from some other accident not belonging to the course of anthrax.

General infection may occur when the primary lesion is seated in the intestinal tract, as well as when the inoculation has taken place on the external surface, and the character of the disease is not essentially different. The primary affection has received the name of "anthrax intestinalis seu abdominalis," "mycosis intestinalis," and is described by Buhl, Waldeyer, E. Wagner, etc. These cases generally run a most alarming, pernicious (*foudroyant*) course, and it is chiefly by examination of the intestine that the identity of the disease has been established. This form of anthrax is generally induced by eating the flesh of infected animals.

General infection of the system corresponds to that period in the development and multiplication of the bacilli, in which they have penetrated beyond the seat of primary infection and, by means of the blood-channels or other paths, have reached the internal organs, and have commenced to multiply in these structures. The bacilli are probably carried by the blood-corpuscles, which often contain them in considerable numbers. The disease progresses much more rapidly in the intestinal form, probably from the sudden liberation of larger numbers of bacilli, which enter the circulation from many points at once.

The anatomical appearançes in anthrax are those dependent upon a multiplication of the bacillary organisms in the body, and there is hardly a structure or a tissue in the dead body in which they may not be found in great abundance. They form thrombi in the capillaries, the lymphatic channels and glands; the brain, kidneys, and intestinal glands are found more or less crowded with them. The most striking changes are hæmorrhages in the tissues, varying in amount from mere points to large extravasations. Œdematous exudations and serous effusions in the various cavities, and serous infiltration in various organs, frequently ensue. The visceral organs are generally found in a normal condition, with the exception of the spleen, which is usually enlarged and softened in structure, and contains enormous collections of bacilli. There is a marked increase in the number of white corpuscles, and death is quickly followed by strongly developed rigor mortis.

In general appearances the clinical picture of fatal anthrax closely resembles that of virulent small-pox. As a rule, cases of malignant pustule terminate fatally in from three to seven days, though in cases of special virulency (*cas foudroyants*) death may occur within a few hours.

The *symptoms* of anthrax are in a general way as follows: Chilliness, or a well-marked rigor, fainting, pains in the limbs, loss of appetite, sometimes severe distress in the region of the stomach, colic, meteorism, vomiting, and diarrhœa, frequently accompanied by bloody stools. There is excessive thirst. The patient retains consciousness to the end, unless coma should supervene shortly before death. Frequently there is great agony and distressing anxiety; the patient begs for relief in the most piteous manner, and feels that dissolution must soon ensue. In other cases there is stupor from the first, or the patient becomes delirious, or sinks into a deep coma, or the body may be convulsed by clonic cramps or continuous trismus or tetanic contractions. Occasionally there is harassing cough and dyspnœa, with bloody expectoration. There may be frequent hæmorrhages in the tissues or from the mucous membranes, and sometimes secondary pustules are formed which are similar in all general characters to the primary lesion. Usually there is considerable elevation of the body temperature at the period of invasion of anthrax, the thermometer often registering 40° C., or higher, for some days, when there is a sudden fall to a temperature at or below normal, frequently as low as 36° C. The pulse is generally accelerated, and increases in frequency until death. The action of the heart is often feeble, and the sounds are hardly audible. Death usually occurs from collapse and general cyanosis.

Cases of intestinal anthrax are generally more virulent than ordinary malignant pustule, and they result fatally sooner than those in which the infection takes place from the external surface. The effects of malignant pustule seem to depend on the mechanical action of enormous masses of germs within the body, and the destruc-

tion of large portions of tissue by the growth and multiplication of the bacilli.

Diagnosis.—The diagnosis is often very far from easy. The most certain method is that of taking a drop from the contents of the pustule or vesicle, which, on microscopic examination, will be seen to contain the bacillus. This at once establishes the character of the disease in distinction from simple non-specific carbuncle and furuncle. In doubtful cases the liquid may be subjected to cultivation in a moist chamber, when a definite result may be obtained within a few hours. Or the experimental inoculation of guinea-pigs and rabbits or other animals susceptible to the disease may be carried out, when the occurrence of anthrax is conclusive of the nature of the disease; but a negative result does not entirely exclude malignant pustule.

In districts in which malignant pustule is known to prevail, the surgeon would suspect this disease in the early stages of simple carbuncle, of furuncle, and in the stings of wasps and other insects. Malignant pustule also resembles the early stages of erysipelas to some extent. Boils or furuncles are frequently very similar in their early stages to the first appearances of anthrax. In certain tissues they also often commence by the development of a vesicle at the seat of irritation. In furuncle, however, there is not so extensive inflammation in the vicinity, and the central gangrene, the crust, the wreath of vesicles, and the febrile action are absent; these symptoms belong exclusively to anthrax. The ordinary simple carbuncle is very painful, the carbuncle of anthrax, on the contrary, is only slightly sensitive. Bites of insects generally show a small yellowish point, which is not observed in anthrax. Erysipelas, especially when accompanied by serous effusions (bullæ), resembles the malignant œdema of anthrax to some extent, but in erysipelas, the chill and fever usually precede the eruption of the disease, while in anthrax, these occur simultaneously.

In glanders the carbuncles are smaller, generally multiple, and accompanied by intense febrile reaction.

Cases of intestinal anthrax, mycosis intestinalis, may be very difficult of diagnosis. The symptoms often resemble those of poisoning by arsenic or phosphorus, though the appearances due to anthrax are frequently more suddenly developed, and advance more rapidly to a fatal termination than in cases of poisoning by these substances. Often the patient is dead within a very few hours.

Prognosis.—The prognosis in anthrax is always very grave, and statistics prove that more than seventy-five per cent. of persons attacked die from the disease. Extensive eruption and multiple pustules render the prospect of recovery less favorable. In children and in feeble persons the disease is almost always fatal. Gravidæ are especially liable to abortion from the invasion of anthrax. When general infection of the system has occurred, the result is uniformly fatal. But two cases of general anthrax are thus far known to have survived the disease (Leube and Massing).

Treatment.—No treatment thus far known is of any avail in malignant pustule, unless it is employed at an early stage in the disease. The complete destruction of the pustule as soon as its nature can be recognized, is the only measure upon which reliance can be placed. If this is not practicable by thorough excision, the carbuncle should be divided by deep incisions, and powerful caustics should be thoroughly applied (carbolic acid, nitric acid, chloride of zinc, bichloride of mercury, or the hot iron). This mode of treatment should be employed even when the disease has existed three or four days, as it has the power of destroying large numbers of bacilli, and may thus be supposed to modify the virulence of the disease, and possibly to allow of recovery in some cases which otherwise would end fatally. The resulting wounds should be treated in accordance with ordinary surgical rules. Internally, the treatment should embrace wine, champagne, coffee, and if signs of failure of the heart appear, carbonate of ammonia, camphor, etc., should be added. If the disease has been induced by the use of infected meat, a prompt emetic should be administered, followed by a cathartic, for the purpose of removing the germs, as thoroughly as possible, from the alimentary canal before general infection of the system occurs. The only medicine which can be looked upon as in any sense a specific is quinine, of which one to two grams should be prescribed in twenty-four hours, and it may be advantageously combined with carbolic acid, one gram per day.

Carbolic acid, in a two to five per cent. solution, may be injected into the diseased tissues in the amount of one gram per day. In cases in which the limbs are the seat of extensive œdema or of gangrene, deep incisions should be made to allow the evacuation of the abnormal products, and antiseptic dressings should be rigidly adhered to until granulations have formed.

The only practicable prophylactic measures for the prevention of anthrax are to prohibit the use of any product or part of diseased animals, to protect the bodies of infected animals from flies and other insects, and to bury them as early as possible deeply in the earth, or preferably to burn them.

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ANTIDOTES. (Deriv., ἀντι and δίδωμι.) Antidotes are remedies which, acting mechanically, chemically, or physiologically, are capable of combating and neutralizing the effects of poisons on the system. They may be divided into three classes, according to their mode of action. (1) mechanical, (2) chemical, and (3) physiological or dynamic.

1 Mechanical Antidotes.—The functions of this class are the removal of poisons as such from the system, and the mechanical prevention of absorption. In this class are included emetics, stomach pump, cathartics, injections, washes, poultices, ligature, tourniquet, etc.

The use of *emetics* is frequently rendered superfluous by the vomiting induced by the poison itself or by the diluent drinks already administered. Where there exists any considerable corrosion of the œsophagus or stomach, or severe abdominal inflammation, their use is contra-indicated. When employed they should be administered without delay, and vomiting should be carried on to such completeness as circumstances will allow. The nature of the poison in each particular case must to a certain extent govern the choice of the emetic to be prescribed, thus common salt is contra-indicated in poisoning by tartar emetic or by corrosive sublimate, and oily substances in poisoning by phosphorus, cantharides, and salts of copper. The emetics include sulphate of copper, sulphate of zinc, tartar emetic, ipecac, emetin, apomorphine, soapsuds, olive oil, melted fats, snuff, etc. In most cases, vomiting may be induced, encouraged, and supported by tickling the fauces with the finger.

Sulphate of copper may be administered in doses of 0.13 to 0.30 Gm. in water. Sulphate of zinc is a very efficient emetic in doses of 1.0 to 2.0 Gm. in 250 Gm. of water. Tartar emetic is slow in action, and it exercises so depressing an effect on the system as to render its use inadvisable when emesis can be otherwise produced. If administered it should be given in 0.1 Gm. doses, once or twice repeated if necessary. Ipecac is best given in the form of powder, the action of the wine and of the fluid extract being too uncertain. The powdered root may be given in 1.0 to 2.0 Gm. doses in warm water, or it may be combined with tartar emetic (Pul. rad. ipecacuanhæ, 1.0; potas. et antimon. tart., 0.05). The alkaloid emetin is an efficient emetic in doses of 0.005 to 0.020 Gm. Apomorphine is in many cases the only emetic possible to introduce, especially when there is resistance or trismus. It is not only a very powerful emetic, but it acts with great rapidity. It is administered by subcutaneous

injection in doses of 0.004 to 0.010 Gm. The common household remedies, salt, mustard, soap-suds, etc., are frequently of great assistance, and they possess the advantage of availability. Common salt is effective when given in the proportion of two tablespoonfuls to a pint of water; mustard in doses of two teaspoonfuls in a cup of warm water; snuff, one teaspoonful in warm water or claret. Olive oil, soap-suds, etc., require no especial mention. Turpeth mineral and sulphate of cadmium are used as emetics, but to only a limited extent; they possess no advantages over others, and it is unnecessary to more than mention them in this connection.

It frequently happens, especially in poisoning by narcotics, that even the most powerful emetics are inoperative. In such cases the *stomach-pump* is a very valuable aid. This instrument has certain advantages over the emetics; the object is attained more quickly, the patient is spared the weakening effects of the emetics, and fluids may be introduced not only for washing out the stomach but for their chemical action on any residuum adherent to the stomach-wall. Should the instrument be not readily obtainable, one may use a common rubber tube to one end of which a funnel is attached. To use this very excellent substitute is a matter of no great difficulty; introduce the free end into the stomach, elevate the other end and pour water or other fluid through the funnel until the stomach and tube are full; then lower the funnel end to make a siphon, and allow the contents of the stomach to escape into a proper vessel. The employment of the stomach-pump is not permissible when the œsophagus and stomach are corroded, on account of the danger of perforation. The instrument is also of no value when the poisonous substance is in the solid form and in large pieces (meat, sausage, cheese, etc.)

Cathartics are frequently necessary when the poison has passed from the stomach into the intestine. Those in most common use are castor oil, croton oil, Epsom salts, senna, etc. Castor oil not only acts as a cathartic, but protects the mucous membranes and obstructs absorption. Its use is contra-indicated in phosphorus and cantharides poisoning, since the absorption of these substances is materially assisted by fats and oils. Croton oil is valuable by reason of its rapid and powerful action. It is best given in pill form (bread-crumb) in doses of one to four drops. Sulphate of magnesium in doses of 4 to 16 Gm. (℥j.–℥iv.) is recommended in chronic lead poisoning, and in connection with certain of the chemical antidotes as an aid in the removal of the resulting compounds from the alimentary canal. Gamboge, senna, croton oil, and other drastics are to be preferred to the cathartics of milder action in narcotic poisoning.

The other physical antidotes above mentioned are employed according to the circumstances of particular cases. Their use is limited almost wholly to poisonous wounds and bites.

2. Chemical Antidotes.—These constitute the class of true antidotes; they act on the poisons themselves rather than against their effects, differing in this respect from the dynamic or antagonistic antidotes. Their action depends upon their property of uniting chemically with poisonous substances, thus altering their chemical and physical character, converting soluble absorbable substances into insoluble or difficultly soluble non-absorbable compounds, or, as the case may be, into compounds which are soluble and absorbable, but harmless. Their use is restricted to those cases in which the nature of the poison is known. Good chemical antidotes should be themselves harmless, even in large excess, easily obtainable, and capable of rapid action. Their employment should not be unnecessarily delayed nor too long continued. They are usually administered in large doses, since it is as a rule impossible to determine the necessary amount with any exactness, but in certain cases the amount given must be carefully regulated, on account of the solubility of the resulting compound in an excess of the antidote; instances illustrative of this point are copper salts with albumen, and the alkaloids and their salts with tannin. In all cases the new-formed compounds, especially when only temporarily insoluble, or insoluble only in the stomach, must be removed by appropriate means with all possible despatch.

The antidotes of this class are divided into (*a*) Organic, and (*b*) Inorganic.

a. Organic Chemical Antidotes.—These antidotes are derived from the animal and vegetable kingdoms, and include substances of widely diverse character. The most important are albumen, milk, gelatine, charcoal, soap, tannin, turpentine, oils, etc.

First in importance is *albumen*, which is adapted for very general use, especially against the inorganic poisons. It is in most cases very easily obtained, it never causes of itself any harm, and it forms more or less insoluble compounds with most metallic salts and mineral acids. Orfila recommended its invariable use, even on mere suspicion of poisoning. It is best administered in fairly dilute form, the whites of four eggs to a quart of lukewarm water. When taken in sufficiently large amounts, it not only unites with the poison to form insoluble compounds, but provides a protecting coating for the mucous membrane, and at the same time may induce vomiting. With hydrochloric, nitric, and sulphuric acids it produces coagula which are more or less soluble in large amounts of water; with phosphoric, acetic, tartaric, and the organic acids generally (tannic excepted), no precipitation occurs. With the corrosive alkalies albumen forms soluble, harmless compounds when given in copious draughts. It forms insoluble albuminates with the alkaline earths and soluble compounds with potassium and sodium. The alums, tartaremetic, and compounds of arsenic are not precipitated. Iodine, bromine, and chlorine unite directly and intimately with the antidote to form harmless compounds. With phosphorus its action is very limited, and of no especial value except as a diluent drink. The presence of any large excess of alkali acts in general to prevent the precipitation of the albumen compounds. The precipitates of albumen with the salts of the heavy metals consist either of a compound of albumen with a basic salt, or, as is claimed, of a mixture of the metallic albuminate with a compound of albumen and the acid of the metallic salt. They are usually soluble in acids and alkalies, and insoluble in excess of albumen. Notable exceptions are the compounds with mercury and copper, which are soluble in a considerable excess of the antidote. The compounds with salts of lead, copper, and zinc are easily dissolved in lactic, acetic, and other organic acids, and in free alkalies. In the case of sulphate of zinc, however, which is precipitated only in very great excess of the antidote, the precipitation is hastened, and rendered more complete by the addition of a small amount of free alkali. Silver salts are easily precipitated; the resulting compounds are partially soluble in excess of common salt. The precipitate with corrosive sublimate, is easily soluble in mineral and organic acids, common salt and similar chlorides, somewhat soluble in sodic phosphate, and in large excess of albumen. The precipitates of the other mercuric salts are less soluble in the same solvents; the mercurous salts are reduced to the metallic form. Other salts with which albumen unites are those of gold, platinum, zinc, antimony (except tartar emetic), and iron. Among the organic poisons which unite chemically with albumen are creasote, aniline, and alcoholic solutions of most of the alkaloids.

In case albumen is not obtainable, recourse may be had to *milk* as a substitute; its action is due to its casein, albumen, and free alkali. Administered lukewarm it is very valuable in poisoning by metallic salts, corrosive acids and alkalies (especially ammonia), and the alkaline earths. Its richness in fat contra-indicates its use where fatty substances are to be avoided.

The value of *gelatine* as an antidote to many metallic salts would be greater if less time were required for its preparation in a suitable form for administration. It must be broken up into small pieces, covered with water, and allowed to soak for about an hour; more water is then added, and the mixture is heated with constant stirring until a fluid of the consistence of honey is

obtained. Its chief value is in poisoning by iodine, bromine, and the alums.

Gluten possesses more or less value as an antidote to certain metallic salts, notably corrosive sublimate. Against the latter it was first recommended in 1820 by Taddei, according to whom thirteen parts will neutralize one part of the poison. It is, however, of much less value than albumen, and is, in addition, quite difficult to obtain.

Tannin, and substances containing it, act as efficient antidotes to many of the organic and inorganic poisons. Tannin forms more or less insoluble compounds with many metallic salts, but it cannot be considered as equal to albumen in efficiency as an antidote to this class of poisons. Tartar emetic is, however, a notable exception, since it is unaffected by albumen, but rendered harmless by tannin, with which it forms an almost insoluble compound. Tannin has considerable value as an antidote to the vegetable poisons ; it precipitates the alkaloids and their salts, and forms compounds which are dissolved only with difficulty. These compounds are of themselves poisonous, and hence must be removed from the system as soon as possible by emetics or drastic purges. Tannin may be given in doses of 0.1 to 0.3 Gm. in two per cent. solution every quarter of an hour. Combined with about one-tenth of its weight of iodine its effect on the vegetable poisons is very much increased. Should tannin itself be not easily obtained, decoctions of substances containing it may be substituted. Among the large number of these may be mentioned tea, coffee, oak bark, willow, cinchona bark, nut-galls, kino, rhatany, and catechu.

Sugar has been recommended in poisoning by the alkaline bases, with which it is supposed to form sucrates. It has also been recommended in poisoning by salts of copper, but just what value it possesses in such cases would be difficult of determination. It is perhaps safe to say that its value with copper salts is *nil*.

Oils possess more or less value in poisoning by corrosive alkalies, metallic oxides and salts, corrosive acids, and carbolic acid. They may be administered alone or with hot water. (Contra-indicated by phosphorus and cantharides.) With the caustic alkalies they unite to form soaps with liberation of glycerine. Their action is, however, slow, and they are on this account of less value than the organic acids in poisoning by alkalies. They are also inferior in value to albumen in the treatment of poisoning by metallic salts. The oils most commonly used as antidotes are olive, cotton-seed, linseed, and almond ; also melted butter and lard.

Starch in the form of paste (one part of starch to ten or twenty of water) is a suitable antidote to iodine and bromine, with which it forms intimate and almost harmless compounds. Its affinity for iodine is less than that of albumen, and the latter is preferable when obtainable. It has some value, but by no means as much as albumen, in the treatment of poisoning by corrosive acids, corrosive sublimate, sulphate of copper, and sulphate of zinc.

Mucilage and mucilaginous drinks, though exerting more or less chemical action, are administered chiefly as protectives against corrosion. They are best made from gum arabic, which is rubbed up with water. Mucilage in copious draughts has been recommended specially for the treatment of poisoning by salts of bismuth.

The use of *turpentine* as an antidote is confined exclusively to poisoning by phosphorus, against which it is beyond question the most valuable remedy. To be capable of acting beneficially it must contain oxygen, which it absorbs with age. When needed, it should be given with all despatch, either alone or in hot water, in doses of about one hundred times the supposed amount of phosphorus ingested.

Charcoal.—In addition to its power of absorbing gases, freshly prepared animal charcoal has, according to many writers, considerable antidotal value in poisoning by metallic salts, phosphorus, and many of the alkaloids. Many consider its value to be restricted to its protective influence on the walls of the stomach. The latter view would seem to be the more reasonable, especially when one considers that the antidote enters into no fixed compounds with mineral or vegetable poisons. Whatever its action on the poisons, however, it cannot be denied that their effects are postponed and considerably slowed. It may be administered in repeated doses of about a tablespoonful, in water, with or without sugar.

Whatever value it has as an antidote is possessed also by wood charcoal, though in a lesser degree.

Soap dissolved in warm water, and in this form administered by the cupful at intervals of a few minutes, is very useful in poisoning by acids and metallic salts, especially corrosive sublimate, bichromate of potassium, and salts of tin and zinc. In contact with inorganic acids the alkaline stearates, palmitates, etc., are decomposed with the liberation of the fatty acids and the union of the alkali of the soap with the acid against which the influence of the remedy is directed. The same result obtains with the metallic salts, except that the metal forms compounds with the fatty acids. This antidote is preferable to the caustic alkalies, since it exerts of itself no corrosive influence ; it is, however, much inferior in value to albumen in most cases.

(*b*) *Inorganic Chemical Antidotes.*—In the administration of this class a more or less exact knowledge of the nature of the poison is even more necessary than for the exhibition of the organic class. The attempts which have been made to compound a universal antidote which would, of course, be equally valuable with or without the knowledge of the nature of the poison, are very numerous, but such an antidote has not been as yet, and, it is safe to say, never will be discovered. These attempted general remedies have in most cases consisted chiefly of substances belonging to the class now under consideration, and several of them are of considerable value, especially when the nature of the poison is unknown. One of the number consists of equal parts of magnesia, oxide of iron, and wood charcoal ; it may be administered freely in moderately large amounts of water. Another, suggested by Jeannel, consists of 2 parts of calcined magnesia, 1 part of washed animal charcoal, 20 parts of water ; when administered it is to be mixed with 2½ parts of ferrous sulphate solution (specific gravity, 1.450) and well shaken. Given in doses of a wineglassful it is itself harmless, and may be productive of much good. When the nature of the poison is, however, known, and an antidote of the inorganic class is indicated, the appropriate remedy is usually exhibited unmixed with other than inert substances (vehicles, diluents, etc.). The antidotes of this subdivision include the following :

Acids.—The acid antidotes belong strictly speaking to both the subdivisions (*a*) and (*b*), since they include both organic and inorganic compounds. The organic acids, indeed, are the ones most commonly used, yet for convenience sake, and on account of other obvious considerations, it would seem not inappropriate to consider both kinds together, with the single exception of tannic acid, however, which is of sufficient importance to be classed alone. Their principal use is in dilute form as neutralizing agents in poisoning by the alkalies and alkaline carbonates. For this purpose the most commonly used are acetic (vinegar), citric (lemon-juice), and tartaric. Very dilute sulphuric acid (one per cent.) is used as a prophylactic against painter's colic, and also in the active treatment of poisoning by soluble salts of barium and lead, with which it forms insoluble sulphates. The vegetable acids are employed also dynamically in the after-treatment of narcotic poisoning.

Ammonia as an inhalation is valuable in poisoning by chlorine, bromine, vapors of corrosive acids, hydrocyanic acid, and nitrobenzole. It is best to dilute the remedy very considerably in order to lessen the pungency of the vapor.

Sodium and potassium carbonates in dilute form may be used as neutralizing agents in poisoning by acids, in the treatment of which, however, they are less valuable than the carbonate of magnesium, since they are less easily tolerated by the stomach. Their employment is still further prejudiced by the fact that in large doses they may cause more or less injury. The mildest in

Antidotes.

their effects are the bicarbonates, which are at the same time the more easily obtained. Their use as antacids is sometimes accompanied by the development of such an amount of carbonic acid as to cause distress by distending the stomach. They are contra-indicated in poisoning by oxalic acid with which they form compounds equally dangerous. Besides their function as antacids they may be used very advantageously in poisoning by iodine and bromine, with which they form harmless salts. Bichromate of potassium when treated with alkaline carbonates is converted to the neutral chromate. The majority of poisonous metallic salts may be decomposed by the bicarbonates, the resulting products being basic carbonates and hydrates, which are insoluble in excess of the reagent. They are recommended particularly in poisoning by the salts of zinc, which are precipitated only incompletely by albumen in large amounts; these salts are immediately decomposed by the bicarbonates with which they form insoluble basic carbonates.

Hydrate and carbonate of calcium (lime-water, chalk, egg-shells, pounded oyster-shells, etc.). These compounds are efficient antidotes in poisoning by the acids, both mineral and organic. They have especial value in poisoning by oxalic acid and the acid oxalates, which substances they not only neutralize but convert to insoluble calcic oxalate. The sucrate of calcium has also been recommended, but it possesses no particular advantages.

The *hydrate and carbonate of magnesium* are beyond question the most efficient and valuable antidotes to the acids and acid salts. Whenever possible it is advisable to administer these preparations in preference to the other antacids already mentioned, except with oxalic acid and the acid oxalates. In the absence of the calcium preparations, however, they may be productive of very good results in the treatment of oxalic poisoning, the resulting oxalate of magnesium being very nearly insoluble. They are superior in value to the carbonates of sodium and potassium in poisoning by bromine, iodine, and bichromate of potassium. The hydrate was recommended by Mandel as early as 1808, as an antidote to arsenic, and by Graf and Berzelius in 1814, as an antidote to arsenic and mercury. By Paulus and Schuchardt it was recommended against corrosive sublimate and other metallic salts. It has been recommended also against phosphorus, especially in connection with the hypochlorite. In contact with solutions of metallic salts its action is to precipitate the corresponding oxides or basic salts. With the arsenic acids it combines to form compounds which are almost completely insoluble in the alimentary canal.

The so-called magnesia of the apothecaries is a compound of magnesic carbonate with magnesic hydrate and water, or a basic carbonate of magnesium. This substance when gently heated parts with its water and carbonic acid, leaving a residue of calcined magnesia, which is slightly soluble, and which, when mixed with about twenty-five times its weight of water, becomes gelatinized, and is then in the proper form for antidotal use. In the process of calcining it is essential that the temperature be kept as low as possible, since when prepared at a high temperature it loses its property of gelatinizing with water. The hydrate may be prepared by precipitating a solution of sulphate of magnesium with sodic hydrate free from carbonate. The precipitate after being well washed may be dried out of contact with the air at a temperature below 100° C.

In the administration in case of poisoning by arsenic, the preparation made from pure calcined magnesia with twenty-five times its weight of warm water, may be given in doses of about 48 to 64 Gm. (℥ jss. to ℥ ij.) at short intervals, then after a few doses at longer intervals until the immediate symptoms disappear, and the magnesium appears abundantly in the fæces. A large excess can do no harm; it acts, indeed, beneficially by stimulating catharsis. In the administration of the compounds of magnesium for their antacid effects it is well to give a considerable excess, which is tolerated without difficulty.

Sulphates of magnesium and sodium (Epsom and Glauber's salts) have especial value in poisoning by soluble salts of barium and lead. The removal of the insoluble sulphates which are precipitated is materially aided by the cathartic action of the excess of the antidote. Their administration may be continued until purging occurs or until the symptoms abate or disappear.

Chloride of sodium (common salt) is perhaps the best antidote to the soluble salts of silver. It should be given in somewhat dilute solution, since concentrated salt solution will dissolve considerable amounts of chloride of silver. By some writers albumen is considered preferable to salt; by others it is recommended to give both together; and by others to administer both singly, the albumen following the salt.

Ferrocyanide of potassium forms insoluble or difficultly soluble compounds immediately on addition to solutions of many salts of the heavy metals. It is in itself a comparatively harmless substance; in large doses it may cause marked dizziness. It is especially valuable in poisoning by salts of copper, in the treatment of which Orfila found it to give as good results as are obtained with albumen. It is not, however, to be preferred to the latter, which is, if only equal in efficiency, certainly more easily obtained. The ferrocyanide may be given in repeated doses of 2.0 to 5.0 Gm. in water.

Chlorine.—The value of chlorine is considerably lessened by its very irritant effects on the mucous membranes. It may be used externally in the form of chlorine water, hypochlorite of sodium (Labarraque's fluid), or hypochlorite of potassium (eau de Javelle), as a wash for snake-bites and other poisonous wounds. The above preparations may be used in dilute form, both internally and as sprays for inhalations; internally in poisoning by alkaloids and vegetable and animal poisons; as inhalations in poisoning by coal-gas (carbonic oxide), ammonia, phosphuretted hydrogen, sulphuretted hydrogen, and prussic acid.

Chlorine water may be administered internally in doses of 4 to 16 Gm. (ʒ j. to ʒ iv.) largely diluted; as a spray for inhalation, a solution of five to ten drops in water. The hypochlorites of potassium and sodium may be administered in doses of 4.0 to 8.0 Gm. (ʒ j. to ʒ ij.), well diluted with water.

Iodine possesses considerable value in the treatment of poisoning by the alkaloids and their salts, by other vegetable poisons, and by snake-bites. It unites with most of the alkaloids to form compounds which are insoluble in water and dilute acids but decomposed by the caustic alkalies, alkaline carbonates, and strong acids. The compounds of the vegetable poisons with iodine are possessed of more or less poisonous properties, and are therefore to be expelled from the system by appropriate means; they are, of course, much less poisonous than the pure bases. Since iodine is itself a very energetic poison, it must be given in very dilute form; the preparation recommended by Bouchardat, and by him considered particularly effective against the vegetable poisons, consists of iodine, 0.20 Gm.; iodide of potassium, 2.0 Gm.; and distilled water, 360.0 Gm.; the dose is from 50 to 100 Gm., frequently repeated according to circumstances. Iodide of potassium is much used as an antidote in the elimination of lead and mercury from the system in cases of chronic poisoning.

Bibron's antidote to the poison of serpents is a mixture of iodide of potassium, 0.016; corrosive sublimate, 0.130; and bromine, 20.0 Gm. Given in good season and in repeated doses of ten drops in wine or brandy, it has been proved to be effectual.

Hyposulphite of sodium in doses of 1.0 Gm., well diluted and frequently repeated, is valuable in poisoning by bleaching-powder (hypochlorite of calcium, "chloride of lime"), Labarraque's fluid (hypochlorite of sodium), and Javelle water (hypochlorite of potassium). Its action is to reduce the hypochlorites to chlorides, undergoing itself oxidation to the sulphate.

Sulphuretted hydrogen has been recommended as an antidote to arseniuretted hydrogen, but its efficacy is yet to be proven.

Iron.—The hydrated sesquioxide of iron is the most efficient antidote to arsenic when the latter is ingested in

soluble form. It was first recommended in this connection in 1834 by Bunsen and Berthold, who proved its efficiency by numerous experiments on dogs and other animals. With arsenious anhydride (white arsenic) it forms, according to Bunsen, a basic arsenite of iron, which is but slightly soluble in the fluids of the digestive tract, but which, on account of its not unpoisonous character, must be removed from the body with all despatch by promptly acting cathartics. By later writers the compound which is formed is considered to be a ferrous arseniate. The union with arsenic is very complete; if an amount of the antidote representing ten parts of ferric oxide be added to one part of arsenic, the filtrate will not reveal even a trace of the poison. In addition to its combining action, it possesses a certain value as a protection to the stomach and intestines against the injurious local effects of the poison. With the arsenic anhydride, and the arsenious and arsenic salts, the union is very limited, even with very large excess of the antidote; the effect is much increased by the addition of a small amount of ammonia or other caustic alkali. In poisoning by the arsenites and arseniates a mixture of the hydrated sesquioxide with basic acetate of iron is more effective. The hydrated sesquioxide is easily prepared by adding ammonia water, sodic or potassic hydrate, sodic or magnesic carbonate, to a solution of ferric chloride or sulphate, or to the tincture of the chloride (tinctura ferri chloridi). The precipitate is thoroughly washed and then mixed with a rather large amount of water. The directions of Bunsen and Berthold for its preparation are to add a small amount of sulphuric acid to a solution of 100 Gm. of ferrous sulphate, then nitric acid, and boil; when cold add an excess of ammonia water, filter and wash, and mix the precipitate with 900 Gm. of water. It is rather better, however, to obtain the antidote by the addition of carbonate of magnesium to a solution of ferric sulphate and avoid filtering and washing; one of the products of this operation is sulphate of magnesium, which adds to the value of the antidote by virtue of its cathartic action.

Since the freshly prepared hydrated sesquioxide undergoes gradual changes which lessen its effectiveness in a very material degree, it is advisable when possible to prepare it as occasion demands. The stability is in direct proportion to the care in preparation, and the purity of the iron salt. Since all warming is to be avoided in the preparation, the solutions used must be considerably diluted. If the antidote is to be preserved for cases of emergency, it is best kept in a cold place and well stoppered.

In the administration of this antidote there are certain points which are to be kept in mind; the poison should be removed from the stomach as completely as possible by emetics or the stomach-pump; the antidote should be freshly prepared if possible, and should be given lukewarm and in large doses (30 to 60 Gm.) at first, at intervals of about ten minutes, and later at longer intervals, until the symptoms disappear and iron appears in the stools. It is perhaps needless to say that treatment should be begun as soon as possible. It is well to follow up the treatment with an active cathartic, on account of the poisonous character and slight solubility of the resulting compound. It has been well shown, experimentally by Schroff, that when the latter substance is itself administered to animals, arsenic may be detected in the urine.

Basic acetate of iron, dialyzed iron, and saccharated iron (ferrum oxydatum saccharatum solubile) have been used with varying success in poisoning by arsenic and arsenious compounds.

Iron filings and reduced iron have, it is claimed, been used with good effect in poisoning by salts of gold, mercury, copper, and other metals. Dose, 2 to 10 Gm. frequently repeated. Sulphide of iron has been proposed as an antidote to mercury, lead, antimony, copper, gold, platinum, tin, arsenic, and other metallic salts, but its value is not proven.

Carbonate of copper in repeated doses of 0.25 to 0.50 Gm. with sugar and water has been recommended in acute phosphorus poisoning, following an emetic. It is supposed to act upon the particles of phosphorus in such a way as to prevent their solution by furnishing them first with a layer of phosphide of copper, and later with one of the metal itself. Its use is to be preceded and followed by emetics.

3. The Physiological or Dynamic Antidotes are remedies which are employed to combat the symptoms or after-effects, and to neutralize the effects of poisons after absorption into the system. As their name implies they do not act on the poison themselves chemically, mechanically, or otherwise, and they are not in this sense true antidotes. *Charles Harrington.*

ANTIMONY. 1. General Medicinal Properties of Compounds of Antimony.—As usual with compounds of the heavy metals all antimonials capable of absorption produce essentially similar constitutional effects. These effects are, in medicinal dosage, depression of pulse in both force and frequency, with fall of arterial tension, diaphoresis, increase of mucous secretions, and, with rise of dosage, nausea and vomiting, with decided muscular debility. In large doses antimonials are powerfully poisonous, causing heart-failure, prolonged and violent vomiting and purging, with cramps, and general collapse. Locally, soluble antimonials, such as that commonest used preparation of antimony, *tartar emetic*, are irritant—much of the emetic effect being evidently due to local irritation of the stomach upon swallowing. Concerning the rationale of the production of the various effects described, the only points of clinical importance are that the effects upon the pulse seem to arise from a direct depressing action upon the heart, and not secondarily from a possible excitation of the restraint-influence exerted through the vagus nerve, and that the vomiting seems to be induced partly by direct local irritation of the stomach, and partly by an action upon the nerve-centres, after absorption. For tartar emetic vomits when injected into the veins but yet not so readily as when given by swallowing.

Therapeutically, antimonials generally are used to depress the pulse in sthenic fever, to hasten the secreting stage in respiratory catarrhs, empirically to oppose the inflammatory process—most notably again in respiratory inflammations, such as pneumonia, and, possibly, to determine vomiting.

2. The Medicinally Used Preparations of Antimony.—The antimonials of the U. S. Pharmacopœia are derived from three compounds of the metal, namely, *antimonious oxide*, *antimonious sulphide*, and *potassio-antimonious tartrate.*

Antimonious Oxide, Sb_2O_3. Antimonious oxide is officinal as *Antimonii Oxidum*, Oxide of Antimony. It occurs as "a heavy, grayish-white powder, permanent in the air, odorless and tasteless, almost insoluble in water and insoluble in alcohol. Nitric acid fails to dissolve it, but it is readily soluble in hydrochloric acid, in warm solution of tartaric acid, and in a boiling solution of bitartrate of potassium." Antimonious oxide exerts the general properties of the antimonials, but is uncertain, doubtless because from its insolubility it must undergo chemical conversion in the stomach before absorption is possible. It is rarely prescribed except in the officinal preparation, entitled:

Pulvis Antimonialis, Antimonial Powder; "James's Powder." This powder consists of thirty-three parts of oxide of antimony, intimately mixed with sixty-seven parts of "precipitated phosphate of calcium." It is white in color, and from the insolubility of its two ingredients is without taste. It is a generally mild but yet uncertain antimonial, available for the antifebrile purposes of the mineral. Dose, for such use, from 0.20 to 0.50 Gm. (three to eight grains) every few hours.

Antimonious Sulphide, Sb_2S_3. Under the title *Antimonii Sulphidum*, Sulphide of Antimony, the U. S. Pharmacopœia makes officinal "native sulphide of antimony, purified by fusion and as nearly free from arsenic as possible." This is the compound commercially known as *antimony*, or *crude antimony*. It is in conical masses of metallic appearance, which, pulverized, yield

a dull, black, odorless and tasteless powder, insoluble in water or alcohol. It is officinal as the source of the following preparation, which, again, is only used pharmaceutically to yield still another:

Antimonii Sulphidum Purificatum, Purified Sulphide of Antimony. The sulphide above described is finely pulverized, the coarser particles separated by elutriation and rejected, and the finer macerated in water of ammonia for five days, then washed and dried by heat. By these manipulations impurities in the native sulphide are gotten rid of, the ammonia serving to dissolve out copper, a common contamination. The purified sulphide is a dark-gray powder of the qualities already detailed. It is used to make the following:

Antimonium Sulphuratum, Sulphurated Antimony. The purified sulphide is boiled in diluted solution of soda, the liquid strained, and while still hot precipitated by diluted sulphuric acid. The precipitate is then washed, dried, and finely pulverized. It appears as a reddish-brown, amorphous powder, odorless and tasteless, and insoluble in water and in alcohol. In composition it is "chiefly antimonious sulphide, with a very small amount of antimonious oxide." Like all the insoluble antimonials, its medicinal action is uncertain, and the preparation is rarely prescribed except as it occurs in the following officinal pill:

Pilulæ Antimonii Compositæ, Compound Pills of Antimony; "Plummer's Pills." These pills are compounded of one part each of sulphurated antimony and calomel, and two parts of guaiac. Each pill weighs 0.13 Gm. (two grains). This preparation had an ancient reputation in the treatment of secondary syphilis, scaly skin eruptions, chronic rheumatism, etc. One or two pills constitute a dose, to be given twice a day.

Besides the foregoing, antimonious sulphide is an essential ingredient of the ancient medicine *Kermes mineral*, formerly officinal in the U. S. Pharmacopœia as "oxysulphuret of antimony." Antimonious sulphide is boiled in a solution of sodic carbonate, and the precipitate that spontaneously falls as the solution cools is washed and dried. Kermes mineral as thus prepared is a soft, dark reddish-purple powder, composed of a mixture of antimonious sulphide and oxide—containing much more oxide than the present officinal sulphurated antimony. It resembles the latter compound in its medicinal virtues.

Potassio-antimonious Tartrate, $2(KSbOC_4H_4O_6)H_2O$. This salt, so well known by the name *tartar emetic*, is officinal under the title *Antimonii et Potassii Tartras*, Tartrate of Antimony and Potassium. It is commonly made by boiling together in water antimonious oxide and acid potassic tartrate (cream of tartar), and obtaining the resulting double tartrate by crystallization from the solution. Other methods, however, are resorted to by some manufacturers. Tartar emetic occurs as "small transparent crystals, of the rhombic system, becoming opaque and white on exposure to air, or a white granular powder, having a sweet, and afterward disagreeable metallic taste, and a feebly acid reaction. Soluble in seventeen parts of water at 15° C. (59° F.) and in three parts of boiling water. Insoluble in alcohol, which precipitates it from its aqueous solution in the form of a crystalline powder" (U. S. Ph.). The pharmacopœial tests for purity are as follows: "A one per cent. aqueous solution of the salt, previously acidulated with acetic acid, should not be clouded by the addition of a few drops of test-solution of chloride of barium (sulphate), or of ferro-cyanide of potassium (iron and other metals), or of oxalate of ammonium (calcium), or of nitrate of silver (chloride). If 1 Gm. of the salt, and some pieces of aluminium wire be added to strong solution of soda (sp. gr. about 1.260), contained in a long test-tube, a gas is given off which should not impart any color to filter-paper wet with test-solution of nitrate of silver, and held over the mouth of the test-tube (absence of more than traces of arsenic)." Aqueous solutions of tartar emetic spontaneously decompose, and are precipitated by acids, alkalies, and alkaline carbonates, soluble salts of lead, and vegetable astringent preparations, such as infusion of galls.

In modern medical practice in the United States tartar emetic is practically the only antimonial used, and is available for all the effects of antimony as already described. In doses of about 0.005 Gm. (one-twelfth of a grain) it depresses the heart and promotes secretion; in doses of about 0.01 Gm. (one-sixth of a grain) repeated, it nauseates, and in doses of from 0.03 to 0.12 Gm. (one-half to two grains) it vomits, with the usual prolonged and distressing attendant nausea of the antimonials. In quantities beyond those last mentioned it is a dangerous and easily fatal poison. It may be given in aqueous solution, and if employed to provoke vomiting, should be prescribed in doses of 0.03 Gm. (half a grain), to be repeated every fifteen minutes until vomiting ensue, or until four doses have been taken. When wanted in small dosage for catarrhs or fevers, the officinal *Vinum Antimonii*, Wine of Antimony, is more commonly prescribed. To make this wine four parts of tartar emetic, dissolved in a little boiling water, is added to "stronger white wine" in such quantity as to yield 1,000 parts of product (1.8 grain to the fluidounce). Wine of antimony keeps far better than aqueous solutions of tartar emetic, but yet will deteriorate in time. From ten to thirty drops is the average dose. Wine of antimony is an adjuvant of the compound *mixture of glycyrrhiza* of the Pharmacopœia. (See Glycyrrhiza.)

Tartar emetic enters into the composition of the officinal compound syrup of squill. (See Squill.)

Tartar emetic, as a soluble antimonial, possesses local properties wanting in the hitherto discussed insoluble compounds. It is, namely, powerfully irritant, and applied to the skin in ointment or plaster produces after a while an eruption, papular at first, but passing to vesicles or pustules, considerably resembling the eruption of small-pox, for which it has actually been mistaken. The eruption is painful, and may leave scars. Pustulation by tartar emetic is a possible, but disagreeable method of effecting a continuous counter-irritation. The best mode of application is to prescribe an ointment of one part of tartar emetic to four of simple ointment, to be rubbed, but rubbed lightly, into the skin. Too vigorous inunction may produce an uncontrollable inflammation.

3. General Therapeutics of Antimony Compounds. *Vascular Depression.*—The power of antimonials to reduce the pulse is unbounded, but in high degree the effect is associated with so much general depression as to be unavailable. Still, in the beginning of a congestion or inflammation, notably of the air-passages, in a vigorous subject, a mild antimonial effect is often most happy. Indeed, so marked often is the benefit, that it is probable that depression of undue vascular excitement is but one factor of the curative influence.

Promotion of Secretion in Catarrhs.—Nauseants generally tend to this effect, but none can compete with antimonials in power. Yet again, the use of antimonials should be confined, except in very small dosage, to the fairly vigorous, and particularly should be avoided in subjects at either extreme of age.

Induction of Vomiting.—Although a powerful, antimony is a poor emetic, since it is slow on the one hand, and unnecessarily nauseant and depressing on the other. Furthermore, the vomiting does not stop when the stomach is empty, as is the case, practically, with the so-called mechanical emetics. For these reasons the emetic operation of antimony is nowadays rarely resorted to.

Relaxation of Spasm.—In full antimonial nausea the concomitant muscular debility may determine relaxation of spasm, as in *laryngismus stridulus*, or may be pronounced enough to be of avail in the reduction of a hernia or dislocation. But for all these purposes an even greater degree of paresis is so easily obtainable by medicines less disagreeable and depressing than antimonials that the latter are seldom resorted to for the therapeusis.

Edward Curtis.

ANTIMONY, POISONING BY. Pure metallic antimony is not thought to be directly poisonous. Symptoms of gastro-enteritis occasionally followed its medicinal use, in times past, and serious symptoms are said to have been produced by the metal when inhaled in the state of

vapor; but the effects in these cases have usually been attributed either to the partial oxidation of the metal or to the presence of arsenic, which is a frequent impurity in commercial antimony. Many of the compounds of antimony are more or less poisonous. The most important of these are tartar emetic, and the terchloride of antimony.

TARTAR EMETIC.—This is a double tartrate of antimony and potassium, and is the most important compound of antimony. It occurs in the form of colorless, slightly efflorescent, crystals, which are usually rhombic octahedrons, or in the form of a white powder obtained by the pulverization of these crystals. It is soluble in about fifteen parts of water at the ordinary temperature, and in less than three parts of boiling water. Tartar emetic may give rise to acute poisoning, as a result of a single large dose, or to chronic poisoning, as a result of small doses frequently administered. Its poisonous properties are due to the oxide of antimony which it contains.

Acute Poisoning, Symptoms.—When a large dose of tartar emetic is taken, the acrid metallic taste of the poison is usually perceived by the patient. After a short time, varying from a few minutes to half an hour, there is nausea and faintness, followed by violent vomiting. There is burning in the throat and œsophagus; sometimes great thirst and difficulty of swallowing; pain in the stomach and abdomen. The vomiting is usually persistent. The vomited matters consist, at first, of the contents of the stomach, then of mucus, later of mucus mixed with bile, and in some cases blood. Violent and persistent purging is usually an early symptom. The discharges are liquid, resembling those of cholera, and frequently contain blood. Symptoms of extreme depression and prostration, ending in collapse, which is a prominent feature in acute tartar-emetic poisoning, soon appear. The skin is cold and covered with perspiration; the pulse, which appears to be increased in frequency till immediately before vomiting sets in, is at this stage diminished in frequency and force, and may become imperceptible; the respiration is irregular, but for the most part slow, with hasty and forced inspiration and prolonged expiration; the temperature is lowered. Cramps in the extremities, delirium, loss of consciousness, and convulsions, not infrequently precede death. The urine in mild cases is increased in quantity, as it is also in the beginning, even in fatal cases; but in such, toward the close, it is generally scanty and bloody, and even suppressed (H. C. Wood, Jr.). Exceptionally, vomiting is absent; in such cases the other symptoms are said to be, as a rule, more prominent. In some cases a pustular eruption, resembling that produced by the external application of tartar emetic, has appeared on the body on the third, fourth, or fifth day. In fatal cases death may occur within a few hours, but is more frequently delayed for two, three, or more days. Recovery is very frequent.

External Application.—Tartar emetic is occasionally employed externally as a counter-irritant, producing sooner or later a burning pain, followed by a pustular eruption, on the parts to which it has been applied. Its use for this purpose has been followed, in several instances, by symptoms of irritant poisoning as a result of its absorption through the integument. In two cases, at least, death has been caused by its application to the broken skin.

Chronic Poisoning, Symptoms.—The symptoms produced by the repeated administration of small doses of tartar emetic are of the same general character as those which have been described under acute poisoning. They are, however, less severe and less rapid in their progress, varying in these respects with the quantity administered and the frequency of the administration. The most prominent are nausea, retching, vomiting of mucous and bilious matters, soreness and constriction of the throat, a sensation of burning and pain in the stomach, a feeling of uneasiness and sometimes pain in the abdomen, a constant feeling of depression, gradual loss of strength, and progressive emaciation. The nausea and vomiting recur after each administration of the poison. Purging is not so prominent a symptom as in acute poisoning. The stools are at first normal; later, there may be diarrhœa, usually alternating with constipation. The time at which death occurs depends chiefly upon the size of the doses and the frequency of their administration. Taylor collected five cases, four of which were fatal. In three, death took place in six, eight, and nine days respectively; in the fourth, the poison was administered over a period of three months preceding death.

Fatal Quantity.—The quantity of tartar emetic required to destroy life cannot be stated with accuracy, since its effects are variable and frequently depend less on the quantity taken than on other conditions. Owing probably to early and abundant vomiting, recovery has frequently taken place after doses varying from from 7.8 to 31 Gm. (2 to 8 drachms). On the other hand, as a result, probably, of idiosyncrasy, alarming symptoms, and even death, have followed the administration of doses which would ordinarily be considered non-fatal. In sixteen fatal cases collected by Taylor, the smallest fatal dose was in a child, 0.048 Gm. (0.75 grain), and in an adult, 0.130 Gm. (2 grains); but in the latter case there were circumstances which favored the fatal operation of the poison. Taylor quotes a case in which 0.022 Gm. (0.33 grain), given in divided doses to a child four years of age, produced alarming symptoms. Serious symptoms have followed the administration of 0.032 Gm., 0.26 Gm., and 0.40 Gm. (0.5, 4, and 6¼ grains respectively) to adults. Dr. Draper reported a case, at a meeting of the Boston Society for Medical Observation, in 1880, in which 0.26 Gm. (4 grains), followed in ten minutes by 0.13 Gm., proved fatal to a healthy adult woman in fifty-three hours. According to Wakley, 0.195 Gm. (3 grains) killed an adult in twenty-four hours; 0.65 Gm. (10 grains) and 0.97 Gm. (15 grains) have proved fatal to children; 2.3 Gm. (36 grains), 2.4 Gm. (37 grains), 3.24 Gm. (50 grains), and 3.9 Gm. (60 grains) to adults. Children, aged persons, and those who are in delicate health are more susceptible to its action than healthy adults. On the other hand, there are certain diseased states of the body in which large and repeated doses have been administered without producing any symptoms of poisoning. Taylor concludes that under favorable circumstances 0.65 to 1.3 Gm. (10 to 20 grains), taken at once, might destroy an adult, and that a still smaller quantity than this might suffice if taken in divided doses.

Appearances.—The mucous membrane of the stomach and intestines is usually more or less inflamed and softened. The inflammatory appearances in the intestines are usually most marked in the duodenum, cæcum, and rectum. The mucous membrane of the mouth, throat, and œsophagus is sometimes inflamed. There are occasionally aphthæ and pustules in the mouth, throat, œsophagus, or stomach; sometimes aphthous ulceration of the glands of the small intestines. The stomach and intestines contain more or less mucus, colored with bile or blood or both. Hypostatic congestion of the lungs has been frequently noticed. A greater or less degree of fatty degeneration of the liver, kidneys, heart, muscular tissue of the diaphragm, and cells of the gastric glands, sometimes recognizable only by microscopic and chemical examination, is a well-recognized result of the action of antimony compounds. This was first pointed out by Saikowsky, who states that there is also a diminution of the amount of glycogen in the liver, and in some cases a total disappearance of it.

Absorption and Elimination.—Antimony is quickly absorbed, and after death may be detected in nearly all the organs and tissues of the body. It is rare to find more than a trace in the stomach, since its emetic properties usually secure its early removal. The liver and kidneys probably contain the largest amount. It is eliminated in the urine and bile, also, according to Lewald, in the milk. When tartar emetic is injected into the veins it is said to be rapidly eliminated through the mucous membrane of the stomach (Brinton). The time required for its complete elimination is uncertain. Millon and Laveran detected antimony in the urine of patients as late as twenty-four days after the last administration of tartar emetic. They also found antimony in the fat, bones, and other

tissues of dogs, as late as four months after the last administration. They state that there are well-marked intermissions in the elimination.

Treatment.—If vomiting has not occurred, it should be provoked by tickling the throat or by the administration of warm water. The best antidote is tannic acid, which forms with oxide of antimony a compound insoluble in water. A solution of the acid may be used. In the absence of this, an infusion of green tea, decoctions of oak-bark, gall-nuts, or Peruvian bark, or tincture of kino or catechu, all of which contain tannic acid, may be administered. The stomach should be thoroughly washed out after the administration of the tannic acid. Opium should then be given, to allay pain and irritation. Stimulants, external and internal, may be required. In the treatment of chronic poisoning it is essential to prevent the further administration of the poison. Stimulants, tonics, and nutritious diet are required.

TERCHLORIDE OF ANTIMONY, BUTTER OF ANTIMONY.—This is a transparent, fusible, crystalline substance, which, on exposure to moist air, rapidly deliquesces to a clear liquid. When pure it is colorless, but it frequently contains more or less chloride of iron, which imparts to it a color varying from yellow to dark-brown. It is decomposed by water, with the formation of hydrochloric acid and an insoluble white basic chloride, which may be distinguished from the corresponding basic chloride of bismuth by its solubility in tartaric acid. A concentrated hydrochloric acid solution of the chloride has some uses, and has given rise to a few cases of accidental or suicidal poisoning. It is a violent corrosive and irritant.

Symptoms.—These resemble closely the symptoms produced by the mineral acids. They come on very rapidly, and consist of violent vomiting and severe pain in the throat, stomach, and abdomen, soon followed by symptoms of collapse. Death has taken place in two hours, and has been delayed for ten and one-half, eighteen, and twenty-four hours.

Fatal Quantity.—The smallest quantity required to destroy life is unknown. Ninety cubic centimetres (three fluidounces), approximatively, of the solution has proved fatal to adults in three cases. Recovery has taken place after thirty cubic centimetres.

Appearances.—The lips, mouth, and throat have usually been found more or less corroded. The interior of the stomach, and upper part of the small intestines is intensely inflamed, corroded, and sometimes black, as if charred. In a case related by Taylor, the whole alimentary canal, from the mouth to the middle of the small intestines, presented this black appearance. The mucous membrane was entirely destroyed, and the parts beneath were so soft that they were easily torn with the fingers. Fatty degeneration of the liver, kidneys, heart, muscular tissue of the diaphragm, and cells of the gastric glands, was observed in rabbits to which small doses of terchloride of antimony were administered (Saikowsky).

Treatment.—This consists in the administration of sodic carbonate, chalk, or magnesia, to neutralize the free acid, and of preparations containing tannic acid.

William B. Hills.

ANTIPERIODICS. This term is applied to those remedies which have a tendency to check certain symptoms having a more or less regularly recurrent type, and dependent etiologically upon those somewhat imperfectly understood influences known as malarial, miasmatic, or paludic. The symptoms against which antiperiodics are most commonly employed are those constituting the seizure in the quotidian, tertian, and quartan types of ague, and consisting of the cold, the hot, and the sweating stages. In the milder forms of intermittent and remittent fever, the breaking up of the recurrent chills as soon as possible is important for the comfort of the patient, but in the so-called "pernicious" malarial fevers, it may be a matter of life or death to stop at once those congestive chills whose effects are so alarming, and it is in such cases that the great value of the antiperiodics is seen. Other chronic manifestations of the malarial cachexia, such as neuralgia, are amenable to antiperiodic treatment, and it is noticeable that the success of quinine in the relief of neuralgia is in proportion to the regular periodicity of the attacks.

By far the most important antiperiodic, of more value, in fact, than all the others taken together, is cinchona, with its derivatives. Ever since the cure of the Countess of Chinchon of an ague at Lima, in the earlier half of the seventeenth century, first gave name and fame to the drug, its value in intermittent fever has been acknowledged. More than any other remedy in the Pharmacopœia it deserves to be considered a specific.

Quinine, by reason of its more concentrated and convenient form, is now used almost entirely to the exclusion of cinchona as an antiperiodic. For this purpose the dose must be large, corresponding in quantity to the so-called antipyretic dose of the drug. The quinine should be so administered as to produce a saturation of the patient's system at the time when the next seizure would occur. To attain this object we may give one full dose, 1 to 2 Gm. (15 to 30 grains) about twelve hours before the expected attack. If the interval is much shorter than this the chance of aborting the very next seizure is diminished. If the single administration of the drug anticipates the chill by only four or five hours, the chances are about equal for and against its success. In no other form is quinine more effective than in that of the crystals of the sulphate in an acid solution (bisulphate) or dissolved in lemon-juice. The solubility is usually somewhat impaired in the pill form, and the administration in coffee fails to give the best effect because of the imperfect solubility of the tannate. Of late the manufacturing chemists have put upon the market a "compound syrup of licorice," which quite effectually disguises the bitter taste of the drug, without, so far as the writer knows, interfering with its solubility.

As the single antiperiodic dose may be either unnecessarily large or else insufficient, and as the elimination may have progressed too far before the time of the seizure, it is better on the whole to administer a number of moderate doses of, say, 0.3 Gm. (5 grains) each, every three hours, beginning twelve hours before the expected time of attack. The amount should be so graduated as to attain and keep a moderate amount of cinchonism, as shown by tinnitus, at the time of the expected attack. When the periodicity of the intermittent fever is irregular, and in cases of remittent fever, cinchonism should be produced as soon as possible after a seizure, and maintained by moderate but sufficient doses for several days. In the cases of pernicious malaria, if there are not ten or twelve hours before the expected time of attack in which to secure complete cinchonism by the oral administration of the drug, it should be given subcutaneously. In order to secure its complete solution, acid must be added, one minim of dilute sulphuric acid to each grain of quinine usually sufficing. But this solution has the disadvantage of being irritating, and there is some danger of abscess. This risk, however, should be taken in preference to that of a severe congestive chill. The hydrobromate of quinine is especially adapted for subcutaneous use. It may be prepared according to the following formula:

℞. Quininæ sulph.................. 10 (gr. clx.)
Acid hydrobromici (Squibb).... 4 (ʒ j.)
Aquæ (vel spts. frumenti)....ad 30 (ad ℥ j.)

The kinate and the disulphate of quinine are preferred by some for hypodermic use. The dose of quinine subcutaneously is less than by the mouth, and its action is more prompt. Where for any reason neither of the foregoing methods are available, the drug may be given by the rectum in doses somewhat larger than by the mouth. For children and others with sensitive stomachs, where haste is not an especial object, quinine may be given by inunction. For this purpose an eligible preparation is the following:

℞. Quininæ sulph................ 5 (gr. lxxx.)
Acid. oleic. pur................ 30 (℥ j.)
Ol. olivarum .... 30 (℥ j.)

Dissolve the quinine in the acid with the aid of gentle heat. Add the oil. The solution should be clear.

The other alkaloids of cinchona, quinidine, chinoidine, cinchonidine, and cinchonine, have some antiperiodic value, but are all inferior to quinine, and if used should be given in larger doses. Regarding the dose of quinine, it should be said that it varies much not only with the individual, but with the place. In the tropics and in the habitat of malaria much larger doses are tolerated and are necessary to break up a chill than in temperate climates and non-miasmatic localities. The prophylactic value of quinine against ague is even greater than its curative action. A moderate amount, as, for instance, a grain three times a day, may be taken constantly for years without any ill effects. This precaution is one that should be taken by every one compelled to live in a malarious country. Even in non-malarious districts persons who have contracted ague elsewhere should, after breaking up the chills by the antiperiodic doses, as described above, continue with small quantities of quinine for a fortnight or more.

Next to cinchona, the most useful antiperiodic which we possess is probably arsenic. It is to those chronic cases which have assumed a somewhat irregular type, and in which we hardly know at what time to expect a chill, that arsenic is particularly adapted. It may be given in the form of Fowler's solution, beginning with 0.3 Gm. (five minims) three times a day, thence carried up to 0.5 or 0.7, or even 1. Gm. three times a day, or the arsenious acid may be given in granules of at first 0.0015 to 0.002 Gm. (one-fortieth to one-thirtieth grain) three times a day, pushed till the physiological effects are reached. With arsenic we do not attempt to stop the very next paroxysm; hence it is not adapted for pernicious cases. It should always be well diluted and given on a full stomach.

When treatment has been delayed until the chill is actually "on," quinine is useless for that seizure, though it is the practice of some to administer it during the paroxysm in the hope of more surely controlling the next attack. Nothing is so efficacious to check a chill actually in progress as a full dose of morphine subcutaneously. Chloroform is also recommended for this purpose in a dose of from 2. to 4. Gm. (ʒ ss. to ʒ j.) in sweetened water or mucilage. Good effects have been claimed for the administration during the chill of nitrite of amyl by inhalation, and nitrate or muriate of pilocarpine hypodermically.

Nectandra, or bebeeru bark, has met with some success as an antiperiodic. The alkaloid in the form of the sulphate of beberine contains whatever of virtue the drug possesses, and may be given in the same doses and at the same times as quinine.

Warburg's Tincture, formerly in much repute, especially in India, as an antiperiodic, contains some sixty-four ingredients, of which the most active is quinia, in the proportion of ten grains to the ounce.

The eucalyptus seems to possess some antiperiodic virtue. Among the peasantry of Southern Europe it has quite a reputation. Careful observation shows that in highly malarious localities it is often without effect. The oil of eucalyptus in doses of 0.1 to 0.3 Gm. (♏ij. to v.), may be given, or the tincture in doses of 1. to 2. Gm. (♏xv. to xxx.). That it is of use in the milder cases is made probable by the fact of its undoubted power as a prophylactic. Since the tree was introduced into Southern Europe in 1856, its growth has much improved the healthfulness of many marshy regions. The Trappist monks have of late years devoted themselves to cultivating this tree in the most malarious regions of Italy, with the result of making places habitable that were formerly highly unhealthy.

Among the other succedanea of quinine, usually most successful when combined with, rather than entirely replacing, that drug, are salicin and salicylic acid, given in doses of 1. to 1.3 Gm. (15 to 20 grains), repeated frequently until tinnitus is induced. The sulphites, especially the sulphite of magnesia and the hyposulphite of soda, have been recommended by some physicians in this country, in doses of 1. to 1.5 Gm. every two hours. The ferrocyanide of iron, despite its disageeable appearance and taste, has been found useful by Flint in doses of 4. to 8. Gm. (ʒ j. to ʒ ij.). Nitric acid in 0.5 Gm. (♏vij.) doses, every six hours, through paroxysm and intermission; the chloride of sodium, given to the extent of 10. Gm. (ʒ ij.) during the intermission; the chloride of ammonium, the iodide of ammonium, and the iodide of potassium, in 0.3 to 0.5 Gm. (5 to 8 grain) doses, repeated and increased; piperine and narcotine, each in doses of 0.2 Gm. (3 grains)—these and other drugs have all had their advocates as being of more or less value in preventing the periodic attacks of ague.

Finally, it remains to allude to two or three classes of drugs under which most of the other numberless remedies that have been suggested against intermittent fever may be classed. Emetics and cathartics, when there is time for their administration, sometimes render the system more susceptible to the action of quinine. Alum, ipecac, sulphate of copper, fraxinus, wahoo, Indian hemp, and the like, probably owe what reputation they have as antiperiodics to this fact; administered alone they would be quite worthless. Some of the simple and aromatic bitters, on the other hand, may, in mild cases, replace cinchona. Anthemis (chamomile), eupatorium (thoroughwort), ilex (holly), parthenium (feverfew), hydrastis, and cascarilla, have a popular, and to some extent a scientific repute in the treatment of intermittent fever, by reason of their bitter quality. When it is remembered that the natural tendency of ague is to recovery as soon as the subject is removed from the source of malarial infection, the antiperiodic value of a large number of the drugs last enumerated will appear quite problematical. *Charles F. Withington.*

ANTIPYRETICS. By an antipyretic is meant an agent possessed of the power of reducing pyrexia. In the widest application of this term it is made to include all agents having a reducing power over an increased temperature, no distinction being made as to the mode of reduction.

The term antipyretic is used in another and more restricted sense, being made to include only those agents which have a direct effect either in diminishing the production of heat or increasing its dissipation.

The difference between these two significations will be made clearer if we take an illustration. Quinine, in malarial poisoning, quickly reduces the high temperature, and is therefore an antipyretic. It is, however, an antipyretic because it acts as an antidote to the poison which causes the rise in the temperature. The temperature falls because the cause of its increase is removed. To illustrate the effect of a direct antipyretic, the action of quinine in typhoid fever may be used. In this case quinine reduces the temperature, not by removing its cause, but by a direct action on the production of the increased heat.

In the former case, the quinine acts as an antipyretic because it removes the cause of the pyrexia, while in the latter it reduces it without influencing its cause; in fact, it may be said that it reduces it in spite of the continuance of its cause.

In the former case the antipyretic effect is brought about indirectly, while in the latter it is brought about directly.

It is only the action of the direct antipyretics that will be considered under this heading. For a description of the indirect antipyretics the reader is referred to the articles on the treatment of malarial pyrexia with quinine and acute rheumatism with salicin and the salicylates.

The knowledge that we at present possess of the mode in which direct antipyretics act is very meagre. The experiments of Lewis, H. C. Wood, and others, although working in a proper direction, have not led to any decisive results.

The following antipyretics will be considered: Quinine, salicylic acid, kairin, and antipyrin.

1. The Action of Quinine as an Antipyretic.—There is a general consensus of opinion that quinine has no influence in reducing a normal temperature.

We have abundant proof that it is able to prevent the increased temperature which attends very active physical exercise.

There is some difference of opinion as to the certainty of the action of quinine in pyrexia. Some believe it is very certain, while others hold the opinion that it is far from being so. It is a daily experience that quinine utterly fails to reduce the increased temperature of certain diseases, no matter in what doses it is given.

The dose of quinine necessary to produce an antipyretic effect must be sufficient to produce what is commonly known as its full physiological effect, or cinchonism, the symptoms of which are ringing in the ears, giddiness, deafness, etc. Doses short of this will not, in the great majority of cases, act antipyretically. It is questionable what, if any, fuller antipyretic effect is obtainable from larger doses than is necessary for the production of cinchonism. It is not by any means certain that 3 Gm. (45 grains) of the sulphate of quinine in the twenty-four hours will have a more decided effect in reducing pyrexia than 1.50 Gm. (22½ grains) given during the same time.

When given in doses of one gram and upward to a person with an elevated temperature the following is the usual result of its action. The temperature commences to fall in about two hours after its administration, and continues falling for a period of about twelve hours. It then commences slowly to ascend, but usually does not reach its original height for twenty-four, or it even may be forty-eight hours. The amount of fall is variable. Sometimes a reduction to the normal is noticed. More frequently, however, a depression of two degrees is all that is brought about. It is exceptional when no appreciable fall takes place.

The pyrexia of some diseases is more readily reduced than that of others. The pyrexia of typhoid fever and pneumonia, for instance, is more easily reduced than that of tuberculosis or of cerebro-spinal meningitis.

Quinine has more power in reducing the temperature during certain periods of febrile diseases than it has at others. In typhoid fever the temperature during the third week is more easily brought down than during the first and second weeks. Further, if the temperature during the third week should suddenly rise after it has attained the normal, it can be much more readily influenced by quinine than at any other period of the disease, provided that the rise is not owing to a relapse. Again, the temperature in mild cases of this disease is much more easily reduced than the temperature in severe cases. This fact can be made use of in the early periods to demonstrate whether we have a severe case or otherwise to deal with. Quickly following the antipyretic action of quinine there is a fall in the rate of the pulse. This is not due to any direct action of the drug on the heart, but is brought about indirectly through the reduction of the fever. When, however, very large doses are administered, a direct cardiac depressant action cannot be eliminated.

Given a case of typhoid fever, or, in fact, of any fever, where the administration of quinine has been followed by a reduction in the temperature, it is a symptom of very serious import when there is not also a consentaneous reduction in the pulse-rate. It is an evidence of very pronounced debility of the cardiac muscle.

We have no positive knowledge as to how quinine acts as an antipyretic. There are, in all probability, several factors in operation in bringing about its effects, such as the partial suspension that it exercises on the oxidizing power of the blood, and the inhibitory influence that it exerts on the migratory and amœboid movements of the white blood-cells. To what extent heat production and heat dissipation are respectively influenced we have no proof: Drs. Wood and Reichert[1] are of the opinion that both processes are increased, the latter especially so.

2. Salicylic Acid.—The antipyretic action of salicylic acid is one of the most important and remarkable therapeutical discoveries of our age. This action, as is well known, is best seen in acute rheumatism; but it is not in this disease alone that the drug has the power of reducing fever. The temperature of typhoid and other fevers is considerably influenced by it.

It has no power to reduce the normal temperature. Ringer,[2] who has closely investigated this subject, found in a few cases a slight increase, probably due, as he suggests, to a catarrhal condition of the stomach, occasioned by the use of the acid. The same writer says that there is no better attested fact than the power of salicylic acid to promptly and considerably reduce an elevated temperature.

It is stated that the fever caused by the injection of putrid material into the blood of the lower animals is not affected by salicylic acid.

When administered to a person in a state of pyrexia, in one or two large doses, or in several quickly repeated smaller doses, the first noticeable effect is profuse sweating, this being shortly followed by a reduction in the temperature. There is no relation between the profuseness of the sweating and the amount of fall in the temperature: it therefore follows that the antipyretic effects are not due to the diaphoresis, as might readily be supposed. This is further proved by the fact that in the exceptional cases where no sweating is induced, the reduction of the temperature is as marked as where it does take place.

In the administration of salicylic acid, the points necessary to be borne in mind are the disturbing effects of very large doses, and the rapidity with which the drug is eliminated. It is best given in full doses at first, until its physiological effects are brought about, and then continued in smaller doses, and repeated frequently enough to keep up such effects for a certain time, the length of time depending on the nature of the pyrexial condition for which it is prescribed. About three doses, of a gram and a quarter each (20 grains), at intervals of two hours, usually occasion decided symptoms of cinchonism. Sixty centigrams (10 grains) every two hours, with the intervals gradually increasing to every three and four hours, will serve to keep up the effects. With the appearance of the symptoms of cinchonism the temperature commences to fall, and if the case is one of acute rheumatism, by continuing the acid in smaller doses, frequently repeated, it is not apt to rise again. In treating cases of pyrexia, other than those of acute rheumatism, it is best to give two or three full doses, some five or six hours before the fever will attain its maximum. It is not advisable to keep up the effects as we do in acute rheumatism. Salicylic acid and the salicylates generally effect a more pronounced reduction of temperature in pyrexia than does quinine. A fall of from 3° to 4° F. is not at all uncommon from the former, while from the latter the average fall seldom exceeds 2° F. Nothing is known as to how this drug brings about its antipyretic effects, either in acute rheumatism or in other forms of pyrexia.

3. Kairin.—Of all the direct medicinal antipyretics kairin is probably the most powerful. No matter what the nature or cause of a pyrexia may be, this drug is powerful to reduce it, when given in doses of about one gram (15 grains) every hour for several hours.

An hour after the administration of a gram of kairin the temperature commences to fall, and in about two hours the lowest point is reached. This generally amounts to 1° C. (nearly 2° F.). The temperature remains down for about an hour, when it begins to ascend, and rapidly reaches its original height. Four hours after the administration of a single antipyretic dose of kairin, there is no evidence that such a dose has been given. In the four hours are included the time during which it is absorbed, and while it acts, together with the subsequent rise of the temperature to its previous height.

If, after giving a gram dose of kairin, a second dose is given at the end of the first hour, we have a further fall of the temperature, and if at the end of the second hour a third dose be administered, we have an additional fall. By continuing to give the drug in this way we can reduce the temperature to the normal, no matter what its height may be and no matter what the cause of the elevation is. The higher the temperature the greater is the quantity of kairin required to effect a reduction to the normal. A temperature of 105° F. requires about four grams (ʒ j.), given in hourly doses of about one gram, while a temperature of 103° F. can be reduced to the normal by three such doses.

The fall in the temperature from the action of kairin

is attended usually by sweating, at times profuse, but it may be absent if the fall takes place very slowly. The sweating is the more profuse the higher the temperature has been, and the more quickly and deeply it falls.

Simultaneously with the fall in the temperature the pulse frequency diminishes.

The ascent of the temperature after the effects of the drug have passed away is sometimes attended with a rigor, but only in cases where it has been reduced to the normal. If it is given in such doses as not to bring the temperature lower than 100° or 101° F., no rigors attend the subsequent ascent.

The antipyretic action of kairin is not enfeebled by giving it even for days. Every gram dose is always followed by a more or less pronounced antipyretic effect.

After the administration of several such doses the urine assumes an olive-green color. This entirely disappears about twenty-four hours after the discontinuance of the drug.

M. Loyd[3] has recently published certain researches on the action of kairin on the blood, which tend to explain its antipyretic action, as well as certain toxic symptoms which sometimes result from its overuse. He finds that this drug reduces the absorption of gases by the blood, and particularly of oxygen. Thus the blood of a dog which, in its normal state, yielded CO_2, 36 C.c.; O, 14 C.c; N, 1.5 C.c, gave, after the injection of a gram and a half (23 grains) of kairin, CO_2, 21 C.c.; O, 3.6 C.c.; N, 1.5 C.c. In other similar experiments the spectroscope showed attenuation and disappearance of the bands of oxyhæmoglobin. These observations throw light on the cyanosis and other kindred phenomena which at times appear, especially after large doses. It is said that the amount of gases in the blood is not affected by small, but is affected by large doses.

Despite the marked antipyretic action of kairin it has no influence in cutting short any of the specific fevers, including pneumonia and acute rheumatism. Although given in several one-gram doses daily in any of these diseases, no direct influence over their course is noticeable. That it brings relief in many cases is undeniable. In pneumonia, especially, the relief supervening upon the fall of temperature is stated to be very marked.

The cyanosis and, at times, cardiac depressant action are serious drawbacks to the every-day use of this drug. It is, however, stated by Guttmann[4] that a chemically pure kairin does not cause the above effects. Erlanger[5] recommends a sulphate of the alkaloid as preferable, and as being free from any marked untoward effects.

Among the minor unpleasant effects of kairin may be mentioned a peculiar itching of the nose, which sometimes amounts to actual pain, and also a dryness of the throat like that produced by atropine. Professor Quinlan,[6] of Dublin, one of the latest writers on the actions of this drug, considers it "a good and safe antipyretic."

4. Antipyrin.—This is the latest addition to the list of antipyretics. It is, like kairin, an alkaloid obtained synthetically from the chinoline series.

In doses of from four to six grams (ʒ j.–jss.) it is a certain and very powerful antipyretic. When given in the above quantities, in divided doses of two grams each every hour, the temperature sinks gradually and continuously, reaching its maximum descent within three or four hours. It generally falls after the first dose of two grams about a degree (Fah.) within an hour. The maximum fall obtained from two or three such doses amounts to from 3° to 5° F. The duration of the temperature reduction is about twelve hours after six grams have been administered. Simultaneous with the temperature reduction there is a fall in the pulse-rate.

If a considerable reduction in the temperature takes place, there is usually copious perspiration. The perspiration can, however, be prevented by the previous administration of half a centigramme (one-twelfth grain) of agaracin, without interfering with the antipyretic actions of the antipyrin. With the exception of occasional vomiting no untoward effects are noticeable from this drug. It does not cause collapse, neither is the ascent of the temperature which occurs after its effects have passed away, attended by rigors, as so frequently happens when kairin is used.

It does not interfere with the appetite, on the contrary, it appears to improve it.

It has been used in a number of febrile diseases, including typhus, typhoid, and relapsing fevers, pneumonia, acute rheumatism, etc. In none of these diseases has it any other than a simple antipyretic action, and therefore, like kairin, it does not influence their course in any way, except in so far as a simple reduction of the temperature may be of favorable moment.

It is not an "antidote" to any of the specific poisons.

It is too soon to say positively that antipyrin will succeed kairin and the other antipyretics. We as yet know too little of its action. That it, however, is a valuable agent there is no doubt, and provided no untoward action attend its use it is destined to fill a very important place in the treatment of febrile disorders. That a pure antipyretic agent like antipyrin is capable of doing much good is shown in the history of the following interesting case, reported by Cohn,[7] of Strassburg: The patient, a female, toward the end of her eighth month of pregnancy, was suddenly prostrated with a severe double croupous pneumonia. On the seventh day of the disease, with a pulse of 132, respiration 58, and a morning temperature of 39.4° C. (102.9° F.), with extremely labored respirations and deep cyanosis, she was in an almost moribund condition. The administration of two doses of antipyrin of two grams each, one at 9 A.M. and the other at 4 P.M., reduced the temperature to the normal, the pulse to 110, and the respiration to 38. The next day the looked-for crisis occurred, after which she slowly recovered.

The Actions of Quinine, Salicylic Acid, Kairin, and Antipyrin Compared.—Before contrasting the antipyretic actions of the above agents, a description of the qualities of a typical agent of this class will not be amiss. We then can more readily understand in how far and in what particular direction each of the above fall short of this hypothetical antipyretic.

A desirable antipyretic would be one possessing the following qualities: First, it should be able to act fairly quickly, but not too rapidly; second, it should be certain in its action; third, its effects should be of several hours' duration; fourth, the subsequent ascent of the temperature should take place gradually; fifth, it should be devoid of untoward effects, especially those of a dangerous nature.

Now if we examine quinine according to this standard, we find that it only fulfils two of the five indications of a desirable antipyretic, the third and the fifth. Its effects are of many hours' duration, and the subsequent ascent is very gradual. No person can claim that quinine is able to fulfil the three remaining qualities. It does not act quickly, and it is far from being certain in its action, and what is still more important, its cardiac depressant action in large doses is so marked, that its use is not unattended with considerable danger. What has been said of quinine applies with almost equal force to salicylic acid. It also fulfils only the third and fourth alleged desirable qualities of an antipyretic. It acts more promptly than quinine, and is probably, on the whole, more certain in its action. It is, however, prone, like quinine, to act as a cardiac depressant, even when given in moderate medicinal doses. It is said that the acid prepared from the oil of winter-green is much less apt to be followed by cardiac debility than that prepared from carbolic acid.

Kairin fulfils the first two qualifications in a manner which leaves almost nothing to be desired, but the marked rigors which attend the ascent of the temperature after its action has passed away, together with the cyanosis and dangerous collapse which are sometimes seen when it is given freely, show that it falls considerably short of what we have taken as our standard of a typical antipyretic.

Antipyrin, so far as we are acquainted with its actions, fulfils more nearly all the functions of a good antipyretic than any of the others. It not only acts quickly, but it is very certain in its action. Its effects are prolonged,

the subsequent ascent of the temperature is gradual, and its action is, so far as is known, free from any dangerous untoward effect.

Antipyrin, therefore, approaches more nearly our typical antipyretic than does any one of the others mentioned.

Compared with the general cold bath at a temperature of 60° or 65° F., all the medicinal antipyretics are less certain and less prompt.

As the cold-bath treatment of fevers will be fully considered under the head of the treatment of typhoid and typhus fevers, it will not be necessary to more than refer to it here.

In hyperpyrexia, no matter how brought about, the cold bath is the only measure that holds out any hope of relief: the actions of all the medicinal antipyretics are too slow to be of much practical use in such a case. In ordinary pyrexia the general cold bath should never be employed where there is distinct evidence of pronounced heart-failure. The cardiac depressant action of a general cold bath is much more marked than that either of quinine or of salicylic acid in the largest doses.

James Stewart.

[1] Journal of Physiology, vol. iii., p. 321.
[2] Handbook of Therapeutics, 10th ed., p. 600,
[3] Progrès Médical, May 10, 1884.
[4] Berl. klin. Wochenschrift, July 30, 1883.
[5] L'Union Médicale, October 4, 1883.
[6] Brit. Med. Jour., December 6, 1884.
[7] Berl. klin. Wochenschrift, September 8, 1884.

ANTIPYRINE. Under the title of *Antipyrine* there has been recently introduced into medicine a new artificial alkaloid discovered by Ludwig Knorr, of Erlangen, and obtained by reaction of acetic ether on aniline, or by oxidation of chinoline. Antipyrine is in the form of a white crystalline powder, of a faint aromatic odor and insignificant bitterness of taste, and is possessed of the unusual advantage, among substances of this kind, of free solubility in water and alcohol. The solutions are neutral in reaction. The effects of antipyrine as reported by Filehne, of Erlangen; Guttmann, of Berlin; May, of Cologne; Rank, of Stuttgart, and Peabody, of New York, are, in substance, the determining of a considerable reduction of temperature in pyrexia, with a coincident fall of pulse-rate, and this without affection of respiration-rate, and without other derangement beyond occasional, but rare, sickening of the stomach, or development of an erythematous eruption of a few days' duration (Peabody). The antipyretic effect is characterized as being of shorter duration than that wrought by quinine—average, about five hours—and, as compared with the effect of kairine, as being free from the abrupt after-rise of temperature and from the initiatory chill attending such rise, which make the kairine-action so objectionable. Antipyrine has, furthermore, the advantage that it can be given conveniently and safely by hypodermatic injection (Rank). The quantity of antipyrine necessary for a pronounced antipyretic effect is stated to be, given by the mouth, from 4 to 6 Gm. (from 60 to 90 grains), which quantity should be administered at hourly intervals in doses not exceeding, each, 2 Gm. (half a drachm). The medicine is readily taken, in aqueous solution, flavored, if desirable, by an aromatic; by which addition the slight taste of the antipyrine will be entirely masked. By the hypodermatic method half the above stated quantities, or less, will suffice. *Edward Curtis.*

ANTISEPTICS. Those agents only which have the power of preventing the putrefactive decomposition of organic material are properly called *antiseptics* (from ἀντί, against, and σηπτικός, putrefying). But inasmuch as these agents have also the power of arresting other forms of fermentation due to the action of micro-organisms of the same class—*e.g.*, the acetic fermentation, the alkaline fermentation of urine, etc.—it will not be necessary to consider antizymotics — a more comprehensive term—separately, and we may accept as satisfactory evidence of antiseptic power the ability of a chemical substance to prevent the development of bacteria of any kind in a medium suitable for their growth. The amount of a given antiseptic agent necessary to accomplish this result is not, however, the same for all species of bacteria, but varies considerably, and can only be ascertained for each species by carefully conducted experiments.

Putrefactive decomposition is a complex process due to the combined or successive action of a variety of micro-organisms, and attended with the formation of a large number of volatile and non-volatile products. The volatile products of putrefaction, many of which are known to us only by their offensive odors, are those which, being recognized by the sense of smell, enable us to distinguish *septic* from other forms of fermentation, and it is a popular error to suppose that an *antiseptic*, or a disinfectant—terms which are often confounded—is an agent which neutralizes these putrefactive odors.

It is true that an antiseptic or a disinfectant may destroy the volatile products of putrefaction. Many agents properly so called have this power; they are not, however, properly so called for this reason. An antiseptic prevents the development of such volatile products by virtue of its power to arrest the process—putrefactive fermentation—which gives rise to them. (For definition of *disinfectant*, see article under that heading.) So, too, as regards the non-volatile products of putrefaction. Some of these are highly poisonous substances which it may be desirable to destroy, and they may be destroyed by certain of the chemical agents recognized as antiseptics; but this power does not entitle such agents to be ranked as antiseptics any more than does the power to destroy the volatile products of putrefaction. We know, as a result of extended experiments, that those agents which restrain the development of septic organisms also restrain the development of known disease-germs, and *vice versa.* We are therefore justified in speaking of those agents as antiseptics which have been proved by laboratory experiments to prevent the development of pathogenic organisms in suitable culture media. Great care, however, must be exercised in drawing any inferences from experiments made upon one organism with reference to the *amount* which may be necessary to prevent the development of another. Thus the bichloride of mercury prevents the development of anthrax spores when present in a culture-fluid in the proportion of 1 to 300,000; whereas some micrococci, and certain bacilli, commonly present in putrefying infusions, can multiply in the presence of 1 to 40,000.

It is evident that an agent which has the power of destroying putrefactive organisms must be an antiseptic. *Germicides* (see this heading) are, therefore, antiseptics. But antiseptics are not necessarily germicides, and, as a matter of fact, some of the best known and most extensively used antiseptics have no germicide power at all, or only destroy the vitality of micro-organisms of this class —bacteria—when used in a concentrated solution and after a comparatively long exposure; *e.g.*, alcohol, common salt, borax, etc.

Certain chemical agents are antiseptics because of their power in very small amounts to precipitate albuminous matters from organic infusions, and thus to render such infusions unsuitable as pabulum for the development of low organisms. This is especially true of the sulphate of iron, sulphate of zinc, chloride of zinc, and other metallic salts which are extensively used as disinfectants. It is difficult to determine whether these substances also exert a restraining influence upon the development of germs, inasmuch as their action upon the organic pabulum essential for such development is manifested almost immediately, when they are added in very dilute solution to a culture-medium. It is probable, however, that those agents which have been shown to possess germicide power—as, for example, the chloride of zinc, which destroys the bacteria of putrefaction in the proportion of one part to fifty—exert a restraining influence upon the development of bacterial organisms in amounts somewhat less than are required for the destruction of vitality. This inference is based upon our knowledge of the antiseptic action of other germicides which do not destroy

our culture-media by causing a precipitation of albuminoid matters contained in them.

Certain substances, which in dilute solution have no restraining power upon the development of low organisms, or may even serve as pabulum for them, in a concentrated solution prevent putrefactive decomposition; *e.g.*, sugar, chloride of sodium, sulphate of magnesia, etc. It is probable that these substances, in concentrated solution, prevent the development of putrefactive organisms by giving a density to the fluid containing them, which is incompatible with the performance of physiological processes—osmotic ?—upon which vital activity depends.

After this brief account of the *modus operandi* of antiseptics we proceed to consider the comparative value of these agents as established by experimental data.

And first we may refer to certain antiseptics extensively employed in the preservation of food products, the use of which is so general and widely known that a mere mention of them is all that will be required in the present place. The list includes sugar, used largely in the preservation of fruits; vinegar, employed for the preservation of certain vegetables; alcohol, used to preserve fruits, and, very extensively, for the preservation of anatomical, pathological, and natural history specimens; and chloride of sodium, our main reliance for the preservation of meats and fish. All of these commend themselves for use by reason of their cheapness and the absence of noxious properties, rather than because of their antiseptic power, which is comparatively low. Every pathologist knows that his specimens are liable to spoil if the alcohol in which they are kept is not of the strength of fifty per cent. or above, and every merchant knows that his "pickled" pork or fish will become putrid in warm weather if the brine in which they are kept is not very "strong."

Attempts to establish the exact antiseptic value of various chemical agents have been made by numerous investigators, but it is hardly worth while to consider any experimental data published longer ago than five or six years, as the methods adopted prior to that time were not such as could give reliable results, and we have more recent data concerning extended researches which conform more nearly with the exactions of science, upon which we shall base our detailed account of the comparative value of antiseptics.

In conformity with the broad sense in which the term antiseptics is used in the present article we shall report facts relating to the power of the agents named in restraining the development of pathogenic micro-organisms, or of those concerned in various fermentations, as well as those relating to their power to prevent putrefactive decomposition, to which a more strict use of the term would limit us.

In attempting to compare the results of different authors it will be necessary to remember that conformity can only be expected in those cases in which the same test-organism has been employed, and in which the conditions, as to the nature of the culture-fluid, etc., have been identical.

When the antiseptic agent is volatile it is evident that the result, in a protracted test, will be influenced by the form of the receptacle and the fact of its being open to the air or hermetically closed, as in the culture-flasks used by the writer. Again, when the conditions of the experiment are such that the "breaking down" of a flask of beef-tea, containing a certain antiseptic in a given amount, as in the experiments of Miguel, depends upon the development of spores or desiccated organisms contained in "dust," or upon accidental inoculation by air-borne spores, the material will be preserved for a longer time than in experiments in which a drop or more of fluid swarming with bacteria is added to the solution at the outset. And the larger the quantity of material containing putrefactive bacteria which is added to a culture-fluid protected by an antiseptic the greater will be its liability to "break down."

In giving a detailed account of the comparative value of antiseptics we shall follow the classification of Miguel,[1] to whom we are indebted for a very comprehensive and carefully conducted series of experiments which have been made during the past two or three years at the Observatory of Montsouris, Paris, in connection with his extended researches relating to atmospheric organisms. The figures given in the following tables also represent the results reported by this author, unless otherwise stated.

The classification of Miguel is as follows:

	Effective in the proportion of
1. Substances eminently antiseptic	1 : 100,000 to 1 : 10,000
2. Substances very strongly antiseptic	1 : 10,000 to 1 : 1,000
3. Substances strongly antiseptic	1 : 1,000 to 1 : 200
4. Substances moderately antiseptic	1 : 200 to 1 : 50
5. Substances feebly antiseptic	1 : 50 to 1 : 10
6. Substances very feebly antiseptic	1 : 10 to 1 : 3.33

In the experiments of Miguel, the amount of each agent tested—in grams—which was required to prevent the putrefaction of one litre of beef-tea was determined, thus giving directly the ratio per 1,000. When an agent failed in the proportion of 300 grams to the litre it was dropped from the list; for, as Miguel says: "In quantities greater than this a substance can scarcely be called an antiseptic, inasmuch as all substances known to chemists, including some of the most fermentable, will preserve indefinitely one litre of bouillon when present in a larger amount than this."

Miguel recognizes the importance of experiments to determine the restraining power of chemical agents upon various species of bacteria, separately, and especially upon "disease-germs," but he says, "As to me, faithful to a plan adopted at the outset, I will treat the subject in a more general manner by making known simply the minimum weight of the substances capable of preventing the evolution of any bacteria or germs."

"The method adopted is very simple. To a liquid always comparable to itself it is sufficient at first to add a known weight of the antiseptic and some atmospheric germs or adult bacteria, and to vary the quantity of the antiseptic until the amount is ascertained which will preserve indefinitely the liquid from putrefaction. In order to obtain germs of all kinds in the dry state it suffices to take them, where they are most abundant, in the dust collected in the interior of houses or of hospitals, and to procure a variety of adult bacteria we may take the water of sewers."

In the writer's experiments, published in *The American Journal of the Medical Sciences* (April, 1883), a different plan was adopted, inasmuch as the object in view was to ascertain the restraining influence of various antiseptics upon several different micro-organisms—isolated in pure cultures—for the purpose of determining whether different species of bacteria have widely different vital resisting power to the action of these agents, or whether results obtained with a single test-organism could be applied to other organisms of the same class. These experiments, which are included in Table No. IV. of my paper referred to, taken in connection with those of Koch on anthrax spores, those of Arloing, Cornevin, and Thomas on the virus of symptomatic anthrax, those of Salmon on the micrococcus of fowl-cholera, etc., show that there are marked differences in the ability of organisms of this class to multiply in the presence of certain antiseptic agents. These differences depend mainly, however, upon the fact that spores are unable to germinate in the presence of very small amounts of certain agents, such, for example, as the bichloride of mercury; and that micrococci and bacilli in process of active growth may develop in the presence of very much larger amounts of these agents.

In the writer's experiments the antiseptic agent, in a given proportion, was added to a culture-fluid; this was then introduced into little culture-flasks of the form

shown in the figure.* The capillary extremity of the flask was then hermetically sealed in the flame of an alcohol lamp, and the contents of the flask sterilized by long boiling in a water-bath. Having now a sterilized culture-fluid containing the antiseptic to be tested in known proportion, it is only necessary to introduce into the flask a minute drop of fluid from a similar flask, containing a "pure culture" of the test-organism, in order to ascertain the restraining power of the agent under trial with reference to this particular organism. By multiplying the experiments we gradually approach the limit and establish the minimum quantity of each agent required to prevent the development of the several test-organisms.

Fig. 186.

The experiments of De la Croix[2] were made by a method which does not differ essentially from that adopted by Miguel.

1. Substances Eminently Antiseptic.

This list, according to the latest researches of Miguel, embraces:

	Efficient in the proportion of
Mercuric iodide	1 to 40,000
Silver iodide	1 to 33,000
Hydrogen peroxide	1 to 20,000
Mercuric chloride	1 to 14,300
Silver nitrate	1 to 12,500

Of the substances included in this list, the bichloride of mercury (mercuric chloride) is that which has heretofore received the greatest attention, and by reason of its comparative cheapness (it can be bought by the thousand pounds for fifty cents per pound) its solubility, etc., it recommends itself at once as an antiseptic of great practical value.

The figures given by Miguel represent the proportion in which this agent will permanently prevent the development of any of the widely distributed micro-organisms in dust deposited from the atmosphere. In the writer's experiments, which have recently been repeated with similar results, it was found that 0.003 per cent., or 1 part in 33,000, prevented the development of the test-organisms employed, while one-half this amount failed—1 to 66,000. These results are not in conflict with those of Miguel, in which the test included a great variety of organisms. In my own recent experiments I have encountered a minute bacillus, associated with other putrefactive organisms, which multiplies in solutions containing 1 to 20,000, but the restraining power of the antiseptic is shown in this proportion by the fact that multiplication is delayed, and does not occur during the first twenty-four hours to such an extent as to interfere with the transparency of the culture solution, and it is only after remaining from forty-eight to seventy-two hours in the culture-oven, at 38° C., that the fluid becomes clouded and is found to swarm with this minute actively moving bacillus. On the other hand, the development of the spores of certain bacilli is prevented by a much smaller proportion. Thus I am able, as a result of recent experiments, to verify the statement of Koch as to the astonishing power of this agent to prevent the development of anthrax spores. A decided restraining power is shown when it is present in the proportion of 1 to 600,000, inasmuch as in a sterilized culture-medium containing this amount, anthrax spores only produce a few flocculi of filaments at the end of forty-eight hours, while in the same medium, without the bichloride, an abundant and luxuriant development occurs in less than twenty-four hours.

In a recent experiment, in which anthrax spores were introduced into two culture-flasks containing 1 to 100,000, two containing 1 to 200,000, and two containing 1 to 400,000, no development occurred during the first twenty-four hours in any of the flasks, while an abundant development had taken place in another flask containing the same culture-medium, without any bichloride, which was inoculated at the same time to test the purity of my stock solution. At the end of forty-eight hours a feeble development of anthrax bacilli had taken place in the two tubes containing 1 to 400,000, while the others still remained clear.

According to De la Croix the development of bacteria in beef-tea is prevented by 1 to 10,250. This is something more than the amount fixed by Miguel, but it must be remembered that these results are all only approximate, and the statement that 1 to 10,250 prevents development, is not to be interpreted as meaning that 1 to 14,300 will not. No intermediate experiment may have been made, for example, between 1 to 10,250 and 1 to 20,500 (referring to De La Croix's experiments). Thus in the writer's experiments, published in *The American Journal of the Medical Sciences*, the standard solution was commonly diluted one-half after each experiment; and, starting with one per cent., we have the following series in experimenting with this agent: .1 per cent., .05 per cent., .025 per cent., .012 per cent., .006 per cent., .003 per cent., .0015 per cent.—in which failure only occurred when the proportion was reduced to .0015 per cent., equal to 1 to 33,333; which proportion may be stated in round numbers, on the safe side, as 1 to 30,000 in the case of the micrococcus of pus. Recent experiments made by the same method, and with the same test-organism, have fixed the limit between 1 to 30,000 and 1 to 40,000. The field is open for those who desire greater exactness to make the experiments for themselves.

2. Substances Very Strongly Antiseptic.

In this table we have:

	Efficient in the proportion of
Osmic acid	1 to 6,666
Aluminium acetate (De la Croix)	1 to 6,310
Aluminium acetate (Kuhn)	1 to 5,250
Chromic acid	1 to 5,000
Chlorine	1 to 4,000
Iodine	1 to 4,000
Chloride of gold	1 to 4,000
Bichloride of platinum	1 to 3,333
Oil of mustard (De la Croix)	1 to 3,353
Hydrocyanic acid	1 to 2,500
Picric acid (De la Croix)	1 to 2,005
Bromine	1 to 1,666
Cupric chloride	1 to 1,428
Thymol	1 to 1,340
Cupric sulphate	1 to 1,111
Salicylic acid	1 to 1,000

We notice first in this group the haloid elements, chlorine and iodine, which by the experiments of Miguel are given the same value—1 to 4,000. This is exactly the value obtained for iodine in my experiments heretofore referred to, in which three different test-organisms were used. According to Buchholz,[3] 1 to 5,714 of iodine prevents the development of bacteria in tobacco infusion. De la Croix fixes the antiseptic power of this agent at 1 to 2,010 for boiled beef infusion, and 1 to 10,020 for unboiled. This would indicate that the nature of the culture-medium employed largely influences the result. In the case of agents which destroy organic matter by oxidation, or which cause the precipitation of albuminoid materials held in solution in our culture-fluids, this must evidently be the case. It is therefore necessary that experiments shall have been made upon organisms contained in culture-media of identical composition, in order that the experiments of one observer may be compared with those of another. And in protracted experiments

* "To introduce a culture-liquid into one of these little flasks, heat the bulb slightly, break off the sealed extremity of the tube, and plunge it beneath the surface of the liquid. The quantity which enters will, of course, depend upon the heat employed, and the consequent rarefaction of the enclosed air. Ordinarily the bulb is filled to about one-third of its capacity with the culture-liquid, leaving it two-thirds full of air, for the use of the microscopic plants which are to be cultivated in it."—(From the writer's recent work, Bacteria, Wm. Wood & Co., New York.)

with chlorine and other gaseous or volatile substances we must take into account the possibility of loss when the receptacle containing the culture-fluid is not tightly closed. Differences of this nature in the conditions may perhaps account for the wide discrepancy of the results by Miguel and by De la Croix with reference to *chlorine.*

The last-named author gives the antiseptic value of this agent in *unboiled* beef-infusion at 1 to 15,606, while Miguel gives it at 1 to 4,000. My own experiments with *chlorine* relate only to its power as a disinfectant. (See article under this title.)

A discrepancy also exists between the results of Miguel and of De la Croix as regards the antiseptic power of *bromine;* the former author places it at 1 to 1,666, the latter at 1 to 5,597.

Again, we have a discrepancy as regards the action of *chloroform,* one author (Miguel) placing it at 1 to 1,250, and the other at 1 to 103.

Oil of mustard, which is said by De la Croix to prevent the development of micro-organisms in unboiled beef-infusion, has been shown by Koch to be capable of preventing the development of anthrax spores in the proportion of 1 to 33,000. According to the same author the *oil of turpentine* destroys the spores of anthrax in five days, and retards their development in the proportion of 1 to 75,000.

Thymol retards the development of these spores in still more dilute solutions—1 to 80,000 (Koch). Buchholz has determined the antiseptic power of this agent in Pasteur's fluid as 1 to 20,000, a result which does not differ greatly from that given by De la Croix for unboiled beef infusion —1 to 1,340.

Sulphate of copper is practically one of the most important agents which appear in this group, and the results of Miguel are in conformity with those of Dougall[4] in giving it a high place as an antiseptic. It is quite extensively used in France, and there can be no doubt of its value from this point of view; but it would be a great mistake to infer from this that it is a reliable disinfectant. (See article under this heading.)

3. SUBSTANCES STRONGLY ANTISEPTIC.

	Efficient in the proportion of
Benzoic acid	1 to 909
Potassium bichromate	1 to 909
Potassium cyanide	1 to 909
Muriate of quinine (Ceri)	1 to 900
Aluminium chloride	1 to 714
Ammonia	1 to 714
Zinc chloride	1 to 526
Mineral acids	1 to 500 to 1 to 333
Thymic acid	1 to 500
Lead chloride	1 to 500
Nitrate of cobalt	1 to 476
Sulphate of nickel	1 to 400
Nitrate of uranium	1 to 356
Carbolic acid	1 to 333
Potassium permanganate	1 to 285
Lead nitrate	1 to 277
Alum	1 to 222
Tannin	1 to 207

Benzoic acid is given a higher value by De la Croix than that given in the table which is taken from Miguel. It is said to prevent the development of bacteria in unboiled meat infusion in the proportion of 1 to 1,439, and to fail in the proportion of 1 to 2,010. According to Koch, 1 to 2,000 retards the development of spores.

The antiseptic power of the salts of *quinine* has been especially studied by Ceri.[5] According to this author the development of bacteria in a culture-fluid inoculated with a drop of turbid fluid from malarial soil is prevented by a solution of muriate of quinine of 1 to 1,900; from 1 to 1,000 to 1 to 1,500 non-putrid development begins. In some recent experiments by the writer a minute bacillus associated with the bacteria of putrefaction developed in the presence of 1 to 800, but the results obtained were, in general, sufficiently in conformity with those reported by Ceri to give confidence in the data he has furnished. The power of this agent to restrain the multiplication of germs in the proportion of 1 part to 800 and above, indicates that its therapeutic value may depend, in part at least, upon a restraining influence exercised upon the development of germs present in the alimentary canal, but our data scarcely justify the belief that in doses commonly administered it is competent to prevent the multiplication of pathogenic organisms in the blood and tissues generally.

According to Dougall, the "salts of the alkaline earths" would occupy a comparatively subordinate position as antiseptics were it not for the extremely high preventive point of *aluminium chloride,* which is given at 1 to 2,000 for hay infusion. This is much beyond the value fixed by Miguel (1 to 714), but may be due to a difference in the culture-medium used in the two series of experiments. Additional experiments with this agent and with aluminium acetate are desirable.

The antiseptic power of *chloroform* is fixed by De la Croix at a much lower figure than that given by Miguel, and is given at 1 to 103. Evidently experiments with this agent cannot be compared unless we know that loss by evaporation has been prevented in both cases.

Zinc Chloride.—The antiseptic power of this salt, which is fixed by Miguel at about 1 to 500, is no guide to its use as a disinfectant—for which purpose it is frequently recommended—inasmuch as my experiments show that 1 part in 50 is required to destroy micrococci, and Koch has shown that anthrax spores are not destroyed by exposure for a month to a five per cent. solution.

The antiseptic power of the mineral acids is given by Miguel at from 2 to 3 Gm. per litre (1 to 500 to 1 to 333). In the writer's experiments *sulphuric acid* prevented the development of all of the test-organisms in the proportion of 1 to 800, and according to De la Croix 1 to 3,353 prevented the development of bacteria in unboiled beef-infusion. The same author states that sulphurous acid (sulphur dioxide) prevents the development of bacteria in the same infusion in the proportion of 1 to 12,649.

Carbolic acid has received special attention from experimenters on account of its extended use, under the teaching of Lister, in surgical practice, and of the popular idea growing out of this, that it is the antiseptic *par excellence.*

Miguel, in his work published in 1883 (*op. cit.*), has given the antiseptic value of this agent as 3.20 Gm. to the litre of *bouillon.* In a later report it is given as 3 Gm. per litre (1 to 333). In the writer's experiments 1 to 500 was found to prevent the development of all the test-organisms, and all of these organisms multiplied in the presence of 1 to 1,000. De la Croix also states that 1 to 502 prevents the development of bacteria in unboiled beef-infusion.

According to Haberkorn[6] the multiplication of bacteria in urine is not prevented by 1 to 100, and Salmon states that the micrococcus of swine plague multiplies abundantly in urine containing 1 to 100. This would indicate that the restraining power of carbolic acid is neutralized by some ingredient in the urine. The germicide power of this agent is also influenced by the nature of the liquid in which it is in solution. Thus Koch states that in solution in oil or in alcohol in the proportion of five per cent. it fails to destroy anthrax spores in one hundred days or more. Anthrax bacilli are, however, destroyed by 1 to 100, while 1 to 850 prevents their development.

4. SUBSTANCES MODERATELY ANTISEPTIC.

	Efficient in the proportion of
Bromhydrate of quinine	1 to 182
Arsenious acid	1 to 166
Boracic acid	1 to 143
Sulphate of strychnia	1 to 143
Arsenite of soda	1 to 111
Hydrate of chloral	1 to 107
Salicylate of soda	1 to 100
Ferrous sulphate	1 to 90
Caustic soda	1 to 56
Citric acid	?
Acetic acid	?

The antiseptic power of *boric acid* was fixed by Buchholz at 1 to 133, tobacco infusion being the fluid employed in his experiments. This corresponds very closely with the figures given by Miquel. But Kuhn states that it failed to preserve a solution of egg albumen in the proportion of 1 to 101. On the other hand, the writer's experiments gave more favorable results for all of the test-organisms employed, and these differed considerably for the different organisms. Thus the micrococcus of pus multiplied freely in the presence of 1 to 400, but failed to multiply in 1 to 200; the micrococcus of septicæmia did not multiply in the presence of 1 to 400, and *B. termo* did not develop in solutions containing 1 to 800. It will be noted that, according to Miquel, the antiseptic power of *salicylic acid* (1 to 1,000) is ten times that of salicylate of soda (1 to 100).

The antiseptic power of *ferrous sulphate* is placed by Miquel at 1 to 90. In the writer's experiments it was found to be efficient in the proportion of 1 to 200 for all the test organisms. It is but fair to state, however, that in these experiments the culture-solutions were not left in the culture-oven longer than forty-eight to seventy-two hours, and it is possible that some of them might have broken down at a later date if the time had been prolonged, for the antiseptic power of certain agents in dilute solutions is often shown by delayed development of micro-organisms subjected to their action, and after a time these organisms may develop freely in the same solution. Whether in this case the agent has been neutralized chemically, or whether the organisms, developing feebly at first, may after a time become habituated to it, is a question not yet definitely settled. The commercial sulphate of iron contains a certain amount of free sulphuric acid which adds to its antiseptic value. The writer's experiments were made with a chemically pure protosulphate, and no doubt Miquel also experimented with the pure salt. It must be remembered that the value of this and other metallic salts as antiseptics is no criterion for their use as disinfectants. In saturated solution the protosulphate of iron does not destroy the vitality of any of the test-organisms experimented upon by the writer, and Arloing, Cornevin, and Thomas assert that a twenty per cent. solution did not destroy the virus of symptomatic anthrax after forty-eight hours' exposure.

5. Substances Feebly Antiseptic.

	Efficient in the proportion of
Protochloride of manganese	1 to 40
Calcium chloride	1 to 25
Sodium borate	1 to 14
Muriate of morphia	1 to 13
Strontium chloride	1 to 12
Lithium chloride	1 to 11
Barium chloride	1 to 10
Alcohol	1 to 10

The writer's experiments give a much higher antiseptic value to *borax* than that reported by Miquel, viz., 1 to 200 for the two species of micrococcus, and 1 to 400 for *B. termo*. De la Croix states that the development of bacteria in unboiled beef-infusion is prevented by 1 to 107. But, as heretofore indicated, the *permanent* preservation of a culture-fluid, exposed to the air, from all kinds of micro-organisms present in the atmosphere, requires a larger amount of this and of other antiseptic agents than is necessary to restrain development for two or three days, when only a few micro-organisms of one of the species mentioned are introduced into a flask such as the writer used in his experiments. The differences in results are probably due, not to error, but to differences in the conditions of the experiments.

According to De la Croix *alcohol* in the proportion of 1 to 20 prevents the development of bacteria in unboiled beef-infusion. It is probable that the figures of Miquel are nearer the mark when the experiment is protracted, for pathologists are aware that their specimens are liable to spoil and to develop a putrefactive odor in solutions containing forty to fifty per cent. of alcohol.

6. Substances Very Feebly Antiseptic.

	Efficient in the proportion of
Ammonium chloride	1 to 9
Potassium arsenite	1 to 8
Potassium iodide	1 to 7
Sodium chloride	1 to 6
Glycerine (s. g., 1.25)	1 to 4
Ammonium sulphate	1 to 4
Sodium hyposulphite	1 to 3

My experiments correspond with those of Miquel in giving to sodium hyposulphite a very low place in the list of antiseptics, and yet this salt has been extensively prescribed as an anti-zymotic agent. If it has any such powers as have been ascribed to it by Pollo and others, it must be in consequence of its undergoing decomposition in presence of certain substances with which it comes in contact in the alimentary canal. In this case the sulphurous acid, if set free, would no doubt act as a potent antiseptic and germicide. But the pure salt introduced into culture-solutions failed entirely to exhibit any restraining power upon the development of the test-organisms up to eight per cent., at which point it was dropped. From Miquel's experiments it appears that when present in more than thirty per cent. the development of micro-organisms in beef-tea is prevented. But in this proportion it is probable that any soluble salt would preserve a culture-solution by giving it a density incompatible with the development of micro-organisms.

George M. Sternberg.

[1] M. P. Miguel, M.D., Chef du service micrographique à l'Observatoire de Montsouris: Les Organismes Vivants de l'Atmosphère, chap. ix., pp. 289–299, Paris, 1883; also article in the Annuaire de Météorologie for 1884.

[2] N. Jalan de la Croix: Das Verhalten der Bakterien des Fleischwassers gegen einige Antiseptica (Arch. f. exper. Path. u. Pharmakol., Leipz., 1880–1, xiii., 175–225).

[3] Antiseptica und Bakterien, Arch. f. exper. Path. u. Pharmakol., iv., 1–81 (1875).

[4] Medical Times and Gazette, London, April 27, 1872.

[5] L'action de la quinine en rapport avec le développement des germes et des organismes inférieurs (Trans. Internat. Med. Cong., Lond., 1881, i., 466–472).

[6] Das Verhalten von Harnbacterien gegen einige Antiseptica. Dorpat, 1879. 8vo.

ANTISEPTICS in Abortion and Labor Cases. The development of the germ theory of disease and the teachings of Mr. Lister on the use of antiseptics, made plain the great importance of cleanliness and the usefulness of antiseptics in surgery. As it became recognized that puerperal fever was due to septic poisoning, the use of antiseptics in preventing it soon became known, and the "Report of the Puerperal Fever Committee of the Berlin Obstetrical Society," December 4, 1877, made by Schröder, Lohlein, A. Martin, Fasbender, and Boehr, settled beyond question the importance of cleanliness and the use of antiseptics in the lying-in room. It was found that a simple rule requiring all attendants and students to wash their hands in an antiseptic solution before making examinations of the lying-in women greatly reduced the death-rate in lying-in hospitals. Until 1876 in many general hospitals there were wards used for lying-in women, and epidemics of puerperal fever were very common, and the death-rate would sometimes reach fifty per centum. For many years the best authorities believed that it would be better to do away with all lying-in hospitals, but now by isolation, cleanliness, and the use of antiseptics the death-rate has been reduced to one or two per centum in some large hospitals of this class. By means of specially constructed buildings, the strict observance of cleanliness, and the use of antiseptics, M. Tarnier, of Paris, has reduced the death-rate to about the half of one per centum.[1] To-day all authorities acknowledge the necessity of cleanliness, and admit that most cases of puerperal fever are due to septic infection; but, notwithstanding the fact that antiseptics have been used by many for the past fifteen years, there are still many in the profession ready to contend that as good results can be obtained without as with

them in the lying-in room. The question now is, How should they be used?[2]

Antiseptics should be used to supplement cleanliness as a preventive of septic poisoning. Before labor begins, and, when possible, before an abortion occurs or is induced, the patient should be thoroughly bathed, and put in clean clothing and bed-linen. The room should be cleared of useless furniture such as would be likely to hold dust, etc. The bed-linen should be kept clean, and changed every day for the first six days after labor.

The doctor and nurse, or other assistants, should always wash their hands in a solution (1 to 5,000) of mercuric bichloride before making an examination, and all instruments to be used should be kept in a solution (1 to 20) of carbolic acid. The vulva should be carefully washed with a solution of mercuric bichloride (1 to 5,000). If the vaginal discharge be fetid, or if the temperature of the patient be above 100° F., a vaginal douche of a warm solution (1 to 5,000) of mercuric bichloride should be given, and repeated if the temperature does not fall. In a prolonged labor the parts should be occasionally washed off with a solution of mercuric bichloride of the given strength, and a napkin wrung out in the same should be kept over the vulva. After the delivery, if instruments have been used, or if the hand has been introduced, the vagina should be washed out with the solution of mercuric bichloride. In all cases the vulva should be washed with the solution and all the linen changed, and an antiseptic pad kept in position over the vulva, and changed every few hours according to the amount of discharge. A napkin wrung out in the bichloride solution answers very well as a pad; but after a few hours the damp napkins become uncomfortable, and it will be necessary to dry them after being wrung out in the solution. Absorbent cotton pads in loose woven nets, with strings at the ends to tie to a pelvic pad, are sold in the shops. These, soaked in the solution of mercuric bichloride, and then dried, make a good and cheap pad. If the perineum be torn, it is well to sprinkle iodoform between the lips of the vulva each time that the parts are washed.

The linen should be kept scrupulously clean, and the pads changed every three or four hours for about a week after labor, and the vulva should be washed with the solution of mercuric bichloride after each movement of the bowels or after passing water. Vaginal douches are not to be used unless the temperature rises above 100° F., then they are to be given every hour until the temperature is again normal. If it continue to rise in spite of the vaginal douches, then intra-uterine douches should be given unless there is positive evidence that the fever is due to some other cause than septicæmia. If the above treatment be employed, puerperal fever will be very rare, and even if infection take place, by the use of vaginal, and—if indicated—intra-uterine injections, most cases of puerperal fever can be aborted in twelve hours. In many cases puerperal fever, when fully developed, can be cured by intra-uterine injections, given every hour or half hour as indicated. Of course, after the centre of infection extends into the Fallopian tubes or peritoneum, or into some tissue beyond the reach of the injections, the local treatment will fail. The best method of using the vaginal douche is to wash the vulva and place the patient on her back, with her hips on a bed-pan, and then, by means of a Davidson syringe with hard-rubber points, inject at least a quart of the warm solution of mercuric bichloride (1 to 5,000) into the vagina. By means of a short piece of rubber tubing a Mercier catheter of large size can be attached to the same syringe and used for intra-uterine injections.

Always before giving an intra-uterine injection the vagina should be thoroughly washed out, for the same reason that we should wash the vulva before giving a vaginal douche. With the patient on the bed-pan, the catheter should be passed into the uterus beyond the os internum, and in abortion cases, where the cervix is rigid, it should be dilated so as to readily admit the catheter and at the same time leave room for the free escape of the solution and any small pieces of débris. It is a mistake to use a solution of mercuric bichloride as strong as 1 to 2,000, as recommended by some recent writers, for of that strength it acts as a strong astringent and interferes with perfect drainage, and makes the next injection, if given within an hour or two, difficult; besides, the danger of mercurial poisoning is great. Even a 1 to 5,000 solution, used twice a day after labor or abortion, for several days, may cause some of the characteristic effects of mercury on the general system. It must not be forgotten that after labor and after some abortions the capacity of the vagina is relatively large, and that therefore, when the perineum is intact, after a vaginal douche is administered to a patient who is lying upon her back, several ounces may be for a time retained in the vagina, and a salt like bichloride of mercury will in a short time pass by osmosis into the general circulation. In some cases of septicæmia it may be necessary to use a douche every hour to kill the local infection and stop septic absorption; in such cases it would be well to alternately use the 1 to 10,000 solution of mercuric bichloride and the 1 to 60 carbolic acid solution (Calvert's No. 1).

Mercuric bichloride is slow in dissolving, and when finely powdered may float undissolved for an hour or more; so it is best to have a carefully made solution, to which water can be added to make any desired strength of solution.

Since it is known that biniodide of mercury is more powerful as a germicide than the bichloride, it may take its place as an antiseptic.

If the germ theory of disease be correct, much may yet be done by using antiseptics internally or hypodermically to stop the development and reproduction of germs in the whole system. A solution of mercuric bichloride (1 to 485) can safely be injected hypodermically without causing any local trouble, and we should not hesitate to use it should we fail to check the disease by the local use of antiseptics. *W. Gill Wylie.*

[1] Traité de l'Art des Accouchements, Tarnier et Chantreuil, p. 801, Paris, 1882.

[2] On the Local Use of Antiseptics after Labor and Abortions, by W. Gill Wylie, M.D., New York Medical Journal, June 23, 1883. Also, The Prevention and Treatment of Puerperal Fever, by T. Gaillard Thomas, M.D., New York Med. Jour., December 15, 1883.

ANTISEPTICS IN SURGERY. The practice of antiseptic surgery is based upon a few broad general principles of which the use of antizymotic drugs or antiseptics is only one feature, but one to which of late such a prominent place has been given that the general reader or student is apt to overlook the others and consider it alone. With the intention of insisting upon the importance and due observation of the other features in their proper place, we can only stop to scan very hastily the history of this particular part of the general subject.*

Paracelsus (1493 to 1560) insisted that nature alone was competent for the task of repairing wounds, and that non-interference was the best policy. Paré was the first to show that gunshot wounds were not poisoned—as had been supposed, though by his treatment he nevertheless converted them into suppurating cavities. He held that the air itself was beneficial rather than injurious to wounds, and that it was the *miasms in* the air rather than the air itself which caused such fatality in sick-rooms, camps, etc.

Delacroix and Arcæus followed these teachings, and even used such antiseptics as alcohol and ethereal oils quite largely. All of these masters insisted on rest and vigorous supporting treatment for the wounded.

Magatus (1516) claimed that the air was full of infectious miasms, and proved it by the rapid decomposition which follows pricking the shell of an egg. Fearing the access of this air he only changed dressings when it became absolutely necessary. While this practice was in many respects good, since more perfect rest of the wound was the result, it was none the less the outcome of a wrong theory.

Wiseman (1692) held much the same views, and used turpentine more or less as a dressing. In 1706 Parmanus

* The writer wishes here to acknowledge his indebtedness to Cheyne's Antiseptic Surgery, of which he has made free use in the preparation of this article.

"speaks of a lotion which he uses for wounds which resists putrefaction, prevents ill accidents, and takes away the inflammation and pain of the wound." During the same year Anel published an account of a method of evacuating abscesses by aspiration without leaving open wounds. Boerhaave (1720) recognized the connection between external wounds and internal abscesses as no one had before him. Heister (1753) used balsams quite extensively, chiefly because they hindered putrefaction.

Percival Pott (1768) arrived at a pretty fair antiseptic dressing for compound fractures, since he sealed his wounds rather effectively; but he also laid stress on the maintenance of proper drainage by openings and counter-openings. B. Bell (1784) used leaden drainage-tubes and very simple dressings. He advised valvular openings for many purposes, especially removal of floating cartilages. The researches of John Hunter (1792) on healing under a scab were of importance, especially as he deduced therefrom the lesson, that it was better to leave the healing process to nature alone. Larrey (1829) believed that the accumulation of blood and consequent tension did more harm than the entrance of air into joint-wounds. Lombard and Percy in 1785 learned that a certain Alsatian had an infallible remedy for wounds. On investigation this turned out to be pure river water used with certain magic phrases; upon trial of the former they praised it highly. Von Kern in 1809 claimed that all that was necessary for the treatment of any wound was—"cold water for arrest of hæmorrhage, then warm water for dressing, some small pieces of lint, absolute rest, and artificial heat." This method was adopted by Von Walther in Bonn, by Fritze in Prague, and by Liston, and until 1860 was generally in vogue in England.

The most important result of this theory, that the air is full of noxious miasms, was the introduction and development of the *subcutaneous method*, as carried out by Delpech, Dupuytren, Dieffenbach, and Stromeyer. The signal successes obtained by this method led to efforts to convert open wounds into subcutaneous ones; and J. Guérin and Chassaignac were largely identified with these endeavors. Much in the same direction was the endeavor by A. Guérin to filter the particulate miasm out of the air by surrounding wounds with large masses of cotton-wool. It must be noted, however, that he thereby achieved two important requisites of proper wound-dressing, viz., elastic compression and a constant temperature.

During the early part of this century attempts were made to substitute other gases for the air in contact with wounds. Oxygen, hydrogen, and carbonic dioxide were the favorites. The complete inutility of this plan was taught when it was demonstrated that *pure* air by itself was not injurious.

About the middle of the present century a favorite routine of treatment was that known as the "open method." Bartscher and Vezin published a description of this in 1856. This method, apparently so opposed to antiseptic practices, has gradually given way under the influence of Lister's teachings, until now scarcely a surgeon of eminence resorts to it. It should nevertheless be pointed out that it is not so directly opposed to the antiseptic method as it appears to be on first thought, since it provides for free drainage, since retention of blood-clot is less likely to occur, and since it is known that bacteria do not grow readily in concentrated fluids such as are those which agglutinate the parts of a wound dressed by the open method.

Another method which partakes largely of the antiseptic character, and which has been in vogue at different periods in the history of surgery, is that by constant or intermittent irrigation or by continuous immersion. Since 1839 Langenbeck's name is inseparably connected with its use.

The antiseptic and preservative properties of coal-tar had been recognized by Chaumette in 1815, and mentioned by Guibourt in 1833, Sivet in 1837, and Bayard in 1846. Calvert had shown that carbolic acid, always present in coal-tar, was a powerful disinfectant, and that it had been used in Manchester in 1857 for the preservation of dead bodies. Stimulated by numerous similar facts laid before a commission of the French Academy, Lemaire studied the subject diligently, and in 1863 published a memoir on the same ("De l'acide phénique"). In this he recognized the germ theory of disease as the actual basis of antiseptic surgery, and was the first to recommend its extensive use in the treatment of wounds. But his work was utterly without system, largely elementary, and carried to no perfection in practice. Such was the condition of affairs when Lister published his first papers, for he had been working for two years independently of any knowledge of Lemaire's experiments. So while remembering that Lister was neither first to show the effect of microbes in causing fermentation, nor was the discoverer of carbolic acid, still, as the originator and elaborator of a well-defined and systematic method of combating the former by the latter, he rendered a service to mankind which will hand down his name to posterity as that of one to whom we owe incalculable gratitude. It matters not that his method has been, and will yet be, modified by many; the grand principles upon which it is based will endure so long as surgery is a branch of the healing art.

LISTER'S OWN WORK.—The first cases which he treated on antiseptic principles were compound fractures of the leg, in 1865. The treatment consisted in a piece of lint soaked in a ten per cent. solution of commercial carbolic acid, and laid on the wound. On the fourth day it was changed, and was again renewed on the eighth. Later this simplest possible dressing was changed in this wise, that purer acid was used, and that the lint was allowed to but slightly more than cover the wound, that the lint was covered with oiled paper, and that this was then covered with a larger piece of wet carbolized lint. Under this dressing formation of a scab was frequent. Next, after such operations as resections the interior of the wound was irrigated with carbolic solution. It was soon found best to take care that none of this should be left in the wound, but that all should be pressed out. Still later, the practice was to encourage healing under a scab by covering the wound with carbolized lint or gauze, and this with a carbolized oil mixed with powdered chalk and spread thickly upon a proper material. In 1867 a fixed method was adopted for opening abscesses. The parts to be opened were carbolized, and the knife immersed before using. The cavity was stuffed with carbolic lint, inserted and removed by carbolized forceps.

In 1868 a species of external protective was made by spreading a carbolized emplastrum upon suitable cloth. By this time he had adopted, first, a carbolized lint over the wound, covered with the plaster just described; over this a gauze wet with carbolized water, with yet another layer of plaster.

The irritative effect of a carbolized application next the skin being well recognized, in 1868 the protective was introduced. At this time also a standard one-to-twenty solution was used for irrigation. A little later the first layer of plaster was modified by a change in its preparation, gutta-percha and shellac being used in its manufacture. In 1869 catgut was introduced as a ligature material. At this time when the dressing was removed a small stream of carbolized water was kept playing upon the part. Finally, in 1871, the carbolized gauze, as we now know it, and the spray, were introduced. Thus Lister first taught us a systematic way of doing what had been rudely and inefficiently done before him, and showed us how to insure a non-septic course for our wounded patients.

It is now necessary before going further to make it clear that the antiseptic method is based on the *germ theory* of *fermentation* and *putrefaction*, and *not necessarily* of infectious disease (Cheyne, "Antisep. Surg.," p. 359). This is not the place to discuss the relations of micro-organisms to surgical diseases, such as erysipelas, septicæmia, pyæmia, etc., nor yet can we do more than allude to the well-known and undisputed fact that some of the lowest forms of vegetable life are the causes of all forms of fermentation and putrefaction. This latter fact once granted, antiseptic surgery finds here its sufficient

raison d'être without necessity for polemical discussion respecting the origin of surgical disease.

Antiseptic methods should be followed, because thereby we exclude bacteria from wounds, and so avoid putrefaction. If, in addition, it happen that by avoidance of decomposition we also avoid surgical infection, so much greater is the advantage accruing from the practice. It matters not whether we hold that the excluded germs are the direct causes of septic disease, or whether alkaloids of decomposition—*ptomaines*—are produced as excretory products and by their presence and absorption cause pathological disturbances. By avoiding one we avoid the other.

Astonishing misconceptions have existed, and do yet exist, concerning the methods as well as the principles of the antiseptic method. Thus many have regarded the spray, which is the most showy feature of the strict Listerian method, as its most important feature, whereas it is the least so, and may even in certain cases be injurious. Others, thinking that the *means* and not the *method* insured success, have disregarded the latter, and have been astonished at their failures. Others yet, believing that the method means cleanliness alone, have tried to carry out this sole principle with varying degrees of success. If instead of cleanliness according to lay notions be substituted strict *surgical cleanliness*, then the method becomes really an antiseptic one, but this is scarcely to be realized without those addenda with which it is so prominently identified.

Before considering applied details it seems worth while hastily to refer to some of those minute organisms whose uninvited and unperceived presence often renders our efforts futile. Are they ever present in the healthy living body, and must they inevitably lead to septic decomposition when present? Innumerable experiments have made it clear that normal blood and normal tissues do not harbor nor favor the development of these germs. Let continuity of tissue be broken, or let the standard of vital resistance be lowered, from any cause, and then the same conditions may not obtain. This has been made so beautifully clear by Chauveau that in justice to the subject we must give here his "*expérience du bistournage.*"

Bistournage is performed by subcutaneously rupturing the spermatic cord by torsion. The testicle thus freed lies separated from nearly all its sources of nutrition, but is protected by its tunics from access of air, which means from access of germs. Its adhesions to the tunica vaginalis are not sufficient to nourish it, and consequently it atrophies. If the blood contain putrefactive germs, then this testicle ought to break down. This it does not do; no germs reaching it either from the blood or the air; it simply disappears by absorption. But if the germs come from without the organism, the fact can be proved as Chauveau proved it. He injected septic organisms into the vascular system of rams. After the fever, when not fatal, had subsided, he performed the *bistournage*, and putrefaction of the testicle ensued. But this was not enough. Lest some might object that the bacteria in the injected fluid were not the active agents, he carefully filtered the liquid to remove them, and then repeated the experiment, but never got the same result. To make assurance surer, and to prove that it was not the infective fever which caused the putrefaction of the organ, he varied the experiment in this way: He injected two rams with the same fluid and the same dose, and then made the *bistournage* on one, with the result that putrefaction followed only in this one case. Furthermore, when he practised the *bistournage* on the left testicle before, and on the right after injection, it was the right only which putrefied. (Quoted from Jeannel's "De l'Infection Purulente." Cheyne.)

Here was a most ingenious proof that the admission of such germs into an organ determines its destruction. Should any one ask, "How, then, does it happen that, when these germs can effect destruction of parts, they do not destroy life?" the answer is at hand;—first, we know that life frequently is lost in this way and from this cause; and second, we know how vigorously we have to combat these organisms when we succeed in saving our patient.

How happens it, then, that after injection of irritating substances, such as, *e.g.*, ammonia, we find septic micro-organisms in the pus thus formed? Without stopping in this place to go over the experimental ground, we are forced to believe that such germs have more or less access to the blood, *via* the lungs and alimentary canal, on account of their minuteness, but that the blood and tissues in a healthy state offer so poor a field for their development that they die from lack of favorable surroundings.

(No reference is made here to the special infectious diseases, each of which is supposed to have its own bacillus, though the fact that the infection does not always follow exposure can be thus best explained.) But in conditions of lowered vitality, depraved nutrition, or in the presence of other diseases, the blood and tissues may become so insensibly altered as to assist instead of preventing their growth. In actual practice we see sepsis and erysipelas occur much more frequently in the exhausted, the debilitated, and the aged than in the young and healthy. No other conclusion than this satisfactorily accounts for known facts.

Another point: The sphero-bacteria seem to be more or less inimical to the more poisonous rod-shaped bacteria; the former very rapidly exhaust the nutritive fluid in cultivating solutions and starve out the latter. It may be a most fortunate thing, then, when the former are present in the blood and wound secretions, for they may serve thus to make things unpleasant for the latter, and either prevent their appearance or hasten their disappearance.

In surgical injuries, micro-organisms may enter the tissues through two different paths: through the blood or by the wound. We take precautions against the first possibility in three ways: 1. We endeavor, as far as possible, to operate upon patients only when they are in good health. 2. When they are reduced or aged, we try to put them through a "building-up process," by which we may restore to the blood and tissues that unknown element vitality, which imparts this resistant power. 3. And when emergency compels us to operate upon those in unfavorable condition we try to impart this power in the speediest possible manner by administration of those remedies which are both stimulant and antizymotic, such as alcohol, quinia, and the like.

As against infection of the wound surface, we have the chain of precautions known as "Listerism," a system which, when scrupulously carried out, makes the entrance or lodgement of any living germ very improbable, perhaps impossible. This system has won its way over incredulity and ridicule, and has left an impress which shall prove an historical monument, no matter what change it may undergo.

Following Mr. (now Sir Joseph) Lister and his disciple, Mr. Cheyne, we ought to distinguish between aseptic and antiseptic surgery. The former includes a series of measures calculated to absolutely exclude every living germ from lodgement on the wound surface or in the dressings. To this end there is perhaps but one known method, and that is the strictest form of Listerism. It is, of course, impossible to say exactly to what extent any of his details could be omitted, or whether any others could be substituted for them; but those who aspire to make the course of a wound perfectly aseptic had best adhere strictly to those directions laid down by their author. It would take a long course of experimenting, which might be trifling with human life, before we could deviate from his plan. Besides, no one could go over the question more carefully than he has done. Let us, remembering that their strict and conscientious observance constitutes our positively aseptic surgery, very briefly run over each detail of the Listerian system; premising that we shall find, as we go over them, ample and admirable reason for each. After strict "Listerism" is rationally appreciated, we shall be better prepared to study its later modifications.

And, first, with regard to general materials, the following are needed for ordinary operations: Carbolic solutions (pure acid in pure water) of two strengths, 1 to 20 and 1 to 40; the former only for the spray and the instruments. A steam spray apparatus; that shown in

Fig. 187 being as convenient as any. The 1 to 20 solution is placed in the glass vessel, and being diluted by the steam, forms a spray of about 1 to 40 strength.

A trough, preferably of porcelain, like that shown in Fig. 188, in which instruments may be covered by the 1 to 20 solution.

Carbolized catgut and silk; for the preparation of which the formulæ in Cheyne's work may be consulted. They are usually bought prepared, ready for immediate use.

Drainage tubing, of *red* rubber, which contains no free sulphur, and so cannot blacken the protective.

Carbolized gauze, made of fine unbleached tarlatan, washed and dried, and then saturated with a mixture of

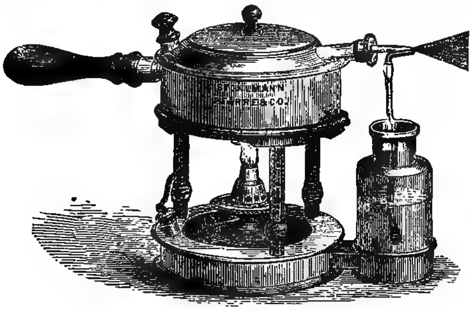


Fig. 187.

paraffin, resin, and carbolic acid. This should be kept in boxes hermetically sealed, since the phenol will evaporate from out of the tightest wrapping. By evaporation much old gauze has thus lost its antiseptic properties and become valueless.

Protective, *i.e.*, an oiled silk, coated with copal varnish, over which a carbolized starch is spread. This latter prevents water collecting in drops on the varnished surface. This protective serves a double purpose: it prevents the carbolic gauze from exercising an irritating effect on tender or fresh raw surfaces underneath; and, as the varnish which coats the silk contains a slight proportion of lead (litharge), it serves also as a tell-tale, since, if decomposition occurs beneath it, sulphuretted hydrogen will be formed, and, by action on the lead of the sulphur thus given off, the protective will be discolored and

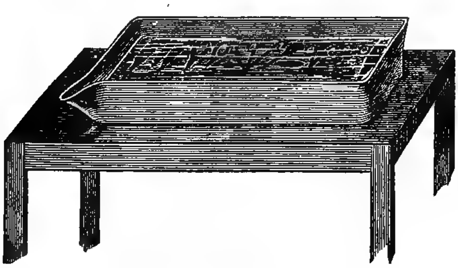


Fig. 188. (From Cheyne.)

blackened. Furthermore, it keeps the outer dressings from sticking to the stitches.

Mackintosh, a cotton cloth with a thin layer of india-rubber spread on one side. It prevents any discharge which may saturate the gauze from soaking through, and is placed outside the main portion of the dressing.

Sponges, and these must be known to be surgically clean.

These constitute the materials required for all usual operations. The *technique* of their use is briefly as follows:

The patient is supposed to have been properly bathed, etc., before the operation. After anæsthesia is produced, the parts are thoroughly washed with the 1 to 20 carbolic solution. Soap should not now be used, since it is known that the acid better permeates and mixes with oily or greasy matters, such as those secreted by the sebaceous glands of the skin, when they are not emulsified with alkalies contained in the soap.

The surgeon and his assistants and nurses *all* wash their hands in the 1 to 40 solution, using the nail-brush carefully. A towel is wet in the 1 to 20 solution and laid on the parts, or between them and the operator; on this instruments may be momentarily laid. The spray is now caused to play upon the parts and the operation is begun, the surgeon taking each instrument, or having it handed to him, from the trough in which it has been lying submerged in a 1 to 20 solution.

As each instrument is used and laid down, it must be placed either on the wet towel or back in the tray. If an

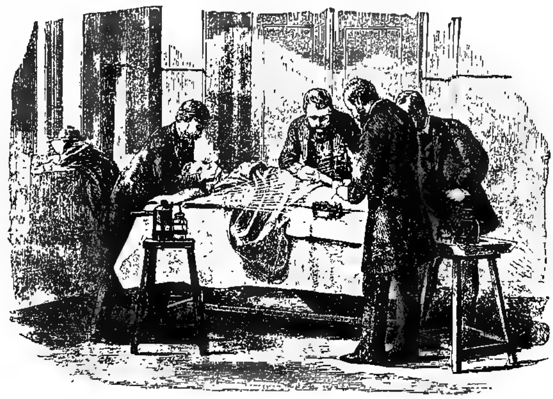


Fig. 189. (Cheyne.)

instrument has been dropped or handled by non-carbolized hands, it is at once carefully carbolized in the tray. The sponges should be wrung out in clean water, and then thoroughly rinsed in the 1 to 40 solution before being again used about the wound.

Vessels, as cut, are either caught in hæmostatic forceps or tied at once with prepared catgut, which can be best kept in and used from such a receptacle as is shown in Fig. 190. The operation being completed, suitable drains are inserted, all clots are removed, and the wound is stitched up with silk or gut, which has also been soaking in the 1 to 20 solution.

After the wound is completely closed a piece of protective but little larger than it, and which has been dipped

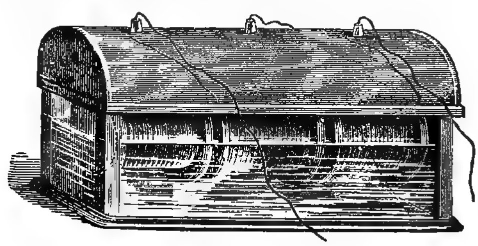


Fig. 190.

in 1 to 40, is applied. Over this is laid a piece of gauze, consisting of several layers, which has been soaking in 1 to 40, and which should widely overlap the protective, say from one to three inches. Any hollows or unevennesses are filled up with loosely crumpled gauze. These together constitute the *deep dressing.* Over this is placed the outer dressing, consisting of eight layers of gauze, and having the mackintosh, rubber side down, underneath the eighth or outermost. This outer dressing must widely overlap the deep dressing, and not until it is properly in place must the spray be intermitted. The dressing is held firmly in place by such bandages as may be necessary, while an elastic bandage is so applied around its edges as to keep them exactly approximated to the contour of the parts. Pins

should not be passed through the mackintosh because they makes holes by which air may gain access to the wound.

A towel or piece of clean rag should always be kept ready soaking in the 1 to 40 solution, in case of accident to the spray, so that it can be thrown over the field of operation to protect it till the spray can be started again.

A solution of zinc chloride, forty grains to the ounce,

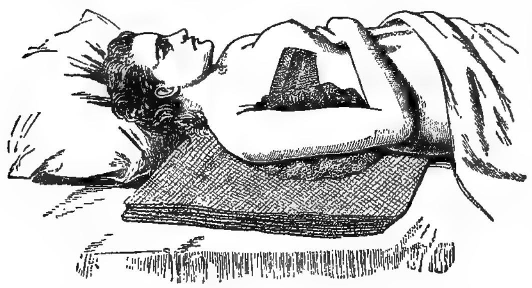


Fig. 191. (Cheyne.)

is also usually provided; with this any foul surface, or sinus, or carious bone can be properly disinfected and cleaned.

The annexed figures, copied from Cheyne's admirable work, may serve to give an idea as to bandage technique.

Figs. 191, 192, 193, show how a patient should be dressed after operation for removal of the breast. Fig.

Fig. 192. (Cheyne.)

191 shows the *deep dressing,* consisting of protective and pads of crumpled gauze, with the outer dressing under the arm, ready to be applied and covered in as represented in Fig. 192. Fig. 193 illustrates an outside binder, so applied as to keep the parts and dressings absolutely at rest.

Fig. 194 represents a dressing suitable for any opera-

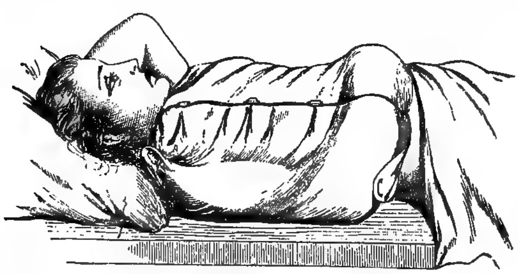


Fig. 193. (Cheyne.)

tion about the region of the sterno-mastoid, behind or below the ear. It will illustrate a ready method of adapting a Lister dressing to the head, neck, or adjoining regions.

Fig. 195 shows the arrangement best adapted for suitably retaining a proper dressing after opening a psoas abscess in the groin, or after resection of the hip-joint, subcutaneous osteotomy of the femoral neck, and similar operations.

Fig. 194. (Cheyne.)

And Figs. 196 and 197 illustrate dressings adapted for cases of herniotomy or operation on the scrotum, or in the groin, seen respectively from the front and from below. The dressings here pictured are among the most difficult to make really efficient, but with a little care and ingenuity every indication can be fulfilled.

And this perhaps is the best place in which to emphasize the necessity of enforcing absolute and perfect rest in the treatment of wounds. It is well known that any freedom of motion, however slight, is liable to at least cause oozing, if not hæmorrhage. This means, besides the formation of blood-clot, such churning up of the exuded fluids as to cause not only irritation within the wound and disturbance of the healing process, but greater liability to fermentation and septic

Fig. 195.

processes within the wound. It should, therefore, be considered requisite in each case to so firmly dress and support the parts, by splints or otherwise, as to preclude the possibility of a reckless or restless patient endangering or jeopardizing his safety by voluntary motion.

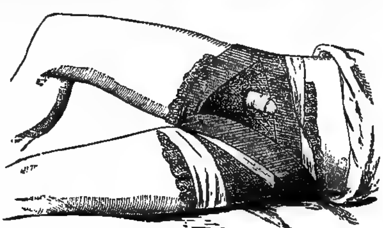


Fig. 196. (Cheyne.)

Such are, in brief, the details of the strict *aseptic* plan of operating and dressing. As will be seen, they are most minute and form a whole whose slightest feature must not be forgotten. Let us remember that their strict and conscientious observance constitutes positively *aseptic* surgery, and, turning our attention to the other part of the subject, let us consider how we can best render our operative procedures and our subsequent dressings, properly speaking, *antiseptic.* Here is offered to us a wide range of choice.

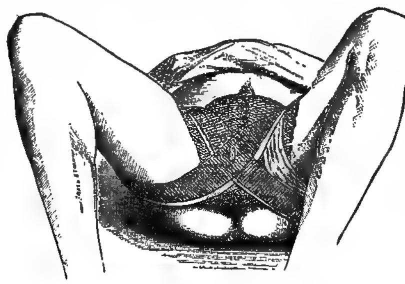


Fig. 197. (Cheyne.)

Moreover, it makes comparatively small difference whether we absolutely exclude germs or destroy them when present; whereas the latter course is the easier, while the good we can accomplish by devising simple and easily applied dressings, which may be brought into most extensive common use, and which shall be genuinely antiseptic, will greatly overbalance any harm that may happen in exceptional cases by omitting to resort to the complicated and expensive Lister method. In other words, we shall, by the one practice, save many more lives than we shall lose by not adopting the other.

Even in 1881 it was a common remark among home and foreign surgeons that little or nothing was left of the original Lister system among those who had been its most enthusiastic advocates. It is, therefore, fitting that we inquire why these details have been dropped or modified. And first of the spray: This is now considered, even by its renowned originator, the least essential part of his system. Several causes have conspired toward its abandonment. In the first place, numerous cases of carbolic-acid poisoning, both of patient and of operator, have been reported as due to its use. Then, too, grave doubts have arisen as to its being as effective as at first supposed. It is, moreover, often a positive disadvantage to the operator. As a consequence, the atomizer is seldom seen either in America or on the Continent. It is, however, a good plan in case one has any reason to be suspicious of the locality in which he operates, to keep one or two large atomizers playing in the room in which the operation is to be performed for an hour or more beforehand. But it is equally important that the room should be warm, and that the operator, nurses, and spectators should be surgically clean, especially when the abdomen is to be opened.

The protective is much less frequently used than formerly, though it will still serve as well as ever to indicate decomposition and to keep the other dressings from sticking to the wound. It is no longer necessary to apply irritating carbolic gauze to the skin, for a layer of salicylic or sublimate cotton, or of borated cotton soaked in boro-glyceride (*vide* below) is preferable. Nevertheless, it is always good practice to use the protective, which should be soaked in sublimate or other antiseptic solution before it is used.

Instead of carbolic gauze we now have numerous substitutes which can be made just as, or more effective. These will be considered below. Their selection may be left largely to the choice of the individual operator.

Cheaper substitutes for mackintosh are now made in abundance; we have very thin rubber cloth, gutta-percha paper, waxed and paraffined paper, etc.; many of them very pliable. These materials may be regarded as, in a measure, duplicates of those employed by Lister. As we gradually depart from his original methods, other ways and means of attaining good results are before us, some of which are well worthy of careful study. An important question is this: If the spray is of doubtful utility, do we need any substitute? Probably we can accomplish as much, or almost as much, by irrigation with some antiseptic solution, preferably one of corrosive sublimate. This may be done occasionally during the operation, and should always be practised just before applying the dressings. If the hands, ligatures, instruments, and sponges be thoroughly antisepticized, *and kept so*, we need feel but little fear for the result. And if the water used for irrigation be quite hot, and allowed to play in fine stream upon the part during the operation, we shall have both an efficient antiseptic and a styptic.

Too much care cannot be paid to seeing that the operator's hands and instruments be surgically clean; *equally so those of his nurses and assistants.* Knives and small instruments with baked rubber handles, with no irregularity or depression about them, not even the maker's name stamped on them, such as Esmarch has recommended, are about the only ones which can be kept surgically clean. It is also essential that the parts to be operated on should be equally clean. To this end the patient should have had a careful and complete preliminary bath, and should be dressed in clean clothes. Then, just at the time of operating, the parts should be shaved and dried, and then sopped with a mixture of spirits of turpentine (one part) with alcohol (two to three parts).

It must be remembered that the instruments are kept in 1 to 20 carbolic solution, and the sponges should have been but very recently removed from the antiseptic solution in which they are habitually to be kept. Instruments after using are replaced in the carbolic solution. Sponges are to be washed, after becoming bloody, in *clean* water, then rinsed in the antiseptic solution selected, before being wrung dry and handed to the assistant; and all this by one who has surgically clean hands and clothes. Sponges which have been dropped had better not be used again; those which have taken up fæces or foul pus should be burned. No casual spectator should touch anything about the patient.

In other words, the operation should be conducted with the same extreme care that is called for in the strictest Listerian plan. Choice of antiseptics may be made from those mentioned below; but those who try sublimate solutions in average strength of say 1 to 1,200 will very seldom wish to employ any other.

During the International Medical Congress (Copenhagen) of 1884, Professor Esmarch read a paper on the antiseptic method, in which he laid down certain postulates for the avoidance of suppuration, which we summarize as follows: 1, Exact hæmostasis; 2, avoidance of cavities in the interior of wounds; 3, drainage, when possible, not by tube but by leaving openings; 4, artificial local anæmia by application of catgut ligatures on large and small vessels; 5, bandage before removal of tourniquet; 6, support of all deep parts by sutures, pressure, etc.

He uses, while operating, a salt solution of the same specific gravity as that of the blood; after operating he uses a sublimate solution. His bandage-strips are also sterilized by dry heat and sublimate. The spray he only uses in the room before operating. The splints with which he immobilizes are made of glass. By such means he attains results as favorable as any.

As one studies the general subject of antiseptic surgery he will find that nearly every Continental teacher of note has some custom peculiar to himself; but this fact simply implies that the student has a wide range of means and methods from which to choose his own; and it is with a view of aiding him in his choice that we give below a list of the more important substances known to possess germicidal properties, stating concisely such facts pertaining to the same as seem most important and indicative.

Aluminium Acetate.—Introduced by Maas, of Freiburg, who recommends a two and one-half per cent. solution in spray, and soaks his compresses and dressings in the same. The salt is free from irritating qualities, and he claims that his cases follow a strictly antiseptic course. According to Sternberg's researches, 1 part in 478 killed bacteria in broken-down beef-tea, while 1 in 584 failed to kill.* It can only be used moist, since when dry it decomposes.

Alcohol.—Bacteria of broken-down beef-tea survive exposure in ninety-five per cent. of alcohol for forty-eight hours. The gonococcus is killed only by a forty per cent. solution. It is in many respects a good antiseptic, but should not be used in weak solutions when this effect is desired. It is worth while here to call attention to the fact which Hack has demonstrated, that granulations treated by alcohol absorb very little, if at all, while those treated by carbolic acid absorb much more readily. On the other hand, alcohol is said to hinder the cicatrizing process.

Benzoic Acid.—One part in 2,000 retards development of spores; bacteria of broken-down beef-tea are only destroyed by 1 part in 77 Volkmann has tested the drug clinically, and found that while wounds generally healed fairly well under benzoated jute, or dressings saturated

* The writer has borrowed largely from Sternberg's studies on bacteria in giving figures of this kind throughout this portion of the subject; and would refer the interested student to his admirable treatise on the subject (Bacteria, Magnin and Sternberg, New York, 1884).

with tincture of benzoin, their course was not uniformly antiseptic.

Bismuth Subnitrate.—The antiseptic properties of bismuth subnitrate were known to Cloquet and Verneuil even in 1860, but have been made much better known by Kocher, of Berne. He suspends it in water in the proportion of one part to one hundred, and uses it thus mixed for irrigation, both during operation and when dressing. Inasmuch as under its use the wound secretes much less fluid, the parts are not united by suture until twenty-four hours after the operation, by which time no drainage is required. Gauze and cotton can be prepared with a bismuth mixture. During the discussion of the subject at the Congress of German Surgeons for 1883, Kocher said that so far as he had studied the *rationale* of its action, he had concluded that the bismuth salt did not directly affect the microbes, *e.g.*, of erysipelas, but rendered their usual nourishment unfit for their support by forming a bismuth albuminate in which they could not grow. He also said he had observed both nephritis and enteritis as a result of mild bismuth poisoning. Kocher's method has found few or no imitators in the United States.

Boric (*boracic*) *acid* kills inferior organisms by depriving them of oxygen. Even in saturated solutions it often fails to destroy test-organisms, but 1 part in 200 prevents their development, and in this fact resides its value. This accounts for the fact that cocci may be present in the pus of wounds treated with boric acid, and yet no sign of putrefaction be present. It is supposed to be absolutely innocuous, but Molodenkow has twice seen undoubted symptoms of poisoning after the use of large quantities of a saturated solution. It was first used as an antiseptic in 1872, in Sweden.

Boric acid is too sparingly soluble in cold water (1 in 30) to be of much service in solution; but stronger solutions may be made by using hot water or by the aid of borax. Its crystals are difficult to pulverize, but this difficulty may be overcome by trituration with a few drops of alcohol. It may now, however, be easily procured in amorphous powder, which may be blown through any form of powder-blower. Cavities that are to heal by granulation may be filled with the powder, as wounds after excisions, sequestrotomies, removal of projectiles, etc.; it offers thus a very safe means of preventing sepsis, and is, moreover, an admirable stimulant to the granulating process. For such purposes its only rival is iodoform, while it has the advantage of being odorless and of practically never causing symptoms of poisoning. Lint and cotton may be steeped in a hot saturated solution; after cooling and drying the fine crystals are deposited in their fibre. Absorbent cotton thus prepared is nearly equal to Lister gauze. When a moist boric acid dressing is wanted it can be best secured in what is known as *boro-glyceride* (*vide* below, Glycerine). Lister has recommended a "boracic ointment" made with boric acid, 1 part; wax, 1 part; paraffin, 2 parts; almond oil, 2 parts. This may often replace the protective, especially about the genitals and anus, where exact antisepsis is difficult or impracticable.

By Thiersch, of Leipzig, boric solutions are used for irrigation, and are made in this proportion: Salicylic acid, 1 part; boric acid, 6 parts; water, 500 parts. If there be ever any cause to object to the use of the sublimate solution this may make an excellent substitute.

Bromine.—Spores are killed by a two per cent. aqueous solution; and the bacteria in broken-down beef-tea destroyed by 1 in 336. It is mostly used as a caustic for foul and sloughing bed-sores, and the like.

Carbolic Acid (*Phenol*).—According to Sternberg 1 in 200 destroys septic cocci, but 1 in 25 does not destroy bacteria of broken-down beef-tea. Still 1 in 500 prevents the development of any of these. De la Croix has stated that a ten per cent. solution is required to destroy bacterial life. Koch has likewise recorded that ten per cent. solutions are necessary for sure disinfection; and that anthrax spores are destroyed in a four per cent. solution only after an immersion of three days. In this connection we must remember that spores are the most resistant of any part of bacteria, and that anthrax spores are the most resistant known. A smaller proportion than that given above is required for mature germs. Koch also has shown that oily solutions of carbolic acid are peculiarly inefficient, and consequently that catgut preserved in carbolized oil cannot be regarded as safe for surgical use, a fact quite in accord with numerous recorded experiences. In his experiments bacilli lived six days in pure oil, and just as long in that containing five per cent. of carbolic acid.

More than this, carbolic acid has a disagreeable effect on fresh tissues, producing a bloody oozing, the fluid permeating dressings rapidly, and thus necessitating early and frequent changes, so that a fundamental principle of antiseptic surgery—rigid rest—has to be violated and the parts disturbed. On various accounts, then, phenol is now much less used in surgery than a few years ago, better substitutes in every respect having been introduced.

The Lister gauze is prepared with the following formula: Carbolic acid, by weight, 50; castor oil, 20; resin, 200; alcohol, 1,000 to 1,500; this is sufficient for the preparation of 500 parts by weight of prepared material.

Chlorine.—Kills bacteria of decomposed beef-tea in proportion of 1 to 1,060, and prevents their development in that of 1 in 15,600. Consequently chlorine water possesses excellent antiseptic properties, though it is scarcely adapted for common use.

Eucalyptus.—Of the oil 1 in 2,500 retards development of spores, though only 1 in 14 kills bacteria in broken-down beef-tea. The leaves were used by Guibert, in 1870, as a dressing for lacerations, etc. Schulz, of Bonn, as well as Baucholtz and Siegen, have made numerous trials with preparations of eucalyptus, and urge their adoption. They all tend to hinder emigration of white blood-corpuscles, and may thus influence suppuration. Schulz directs that for the spray the glass reservoir should be filled with an alcoholic solution of the oil, which the steam can take up and emulsify. But odor and expense serve to tell against eucalyptus preparations. It may also be used in the manufacture of gauze. Lister's own researches and experiments have proved very encouraging. Lastly, its non-poisonous and antimalarial properties should be greatly in its favor.

Glycerine.—Introduced into surgery in 1855 by Demarquay It was first tried in hospital gangrene, and then in all kinds of wounds. Although it seems inert as regards spores of bacilli, it nevertheless possesses remarkable preservative power, for which purpose it has been largely used by the writer (*Annals of Anat. and Surg.*, February, 1882, p. 120), who has usually found that the more severe the test the more satisfactory the result.

Glycerine possesses properties calculated to make it peculiarly valuable in surgery. It is not only a solvent of many of the solid antiseptic drugs, but is freely miscible with water, and does not evaporate on exposure to the air. A glycerine dressing is therefore not liable to stick to a wound, while the parts can be easily cleansed with a stream of water. In this last respect it is immeasurably superior to oil. Further, Mosetig-Moorhof has shown that it has a greater specific gravity than pus, and hence can be used to great advantage in deep cavities which it is difficult or impossible to drain. Introduced into these, the pus rises to the top, and can be floated off as fast as formed.

Boric acid is soluble in hot glycerine in the proportion of three parts to eight, though it requires some care to make the solution thus strong; but two parts of the acid are easily dissolved in eight, the solution still retaining the usual fluidity of glycerine. By this means the antiseptic properties of both are combined in what is known as *boro-glyceride.* It makes a most admirable dressing, especially for plastic operations and scalp wounds, since the glycerine takes up the watery portions of the blood as poured out.

Corrosive sublimate also dissolves with remarkable readiness in glycerine, and a very strong solution can thus be kept on hand for reducing to any desired strength; or a sublimated glycerine (1 to 500–1,000) may be used instead of boro-glyceride.

By aid of alcohol and heat, glycerine may also be impregnated with a small proportion of naphthalin (q. v.), but enough to make it smell strongly, and share the peculiar properties, of the latter. This mixture may be used just as is boro-glyceride.

Iodine, in proportion of 1 to 1,000, destroys septic cocci, while the bacteria of decomposed beef-tea are killed by 1 in 410. Its antiseptic properties were first pointed out by Magendie and others, in 1852. Since then it has been largely used, but of late has been rather replaced by other drugs. When a stimulating antiseptic is wanted, a three to ten per cent. solution of the tincture may be made very serviceable.

Iodoform.—Introduced into systematic use as an antiseptic by Mosetig-Moorhof, of Vienna, in 1880. Its introduction has. certainly advanced the possibilities of surgery. Practically insoluble in water, it furnishes us a solid antiseptic capable of withstanding the solvent action of the fluids and excretions of the body. Formerly the great danger after such operations as extirpation of the larynx, thyroid, tongue, rectum, uterus, etc., was from purulent infection, because by the very nature of the cases a strictly antiseptic dressing was impossible. Now they are made practicable and almost safe. In spite of the advantages which it furnishes us, it has had some bitter enemies; but as experience has taught its more judicious use, it is likely to long remain in favor. It has been charged that under its use erysipelas has happened more frequently than under the Lister dressing. Reports from some sources have seemed to confirm this, yet erysipelas is rare when using it, the writer having as yet but once observed it; and it still stands without a rival for many purposes.

Symptoms of what is known as "iodoform intoxication" have been less rare, though still very uncommon. These symptoms have generally consisted of those of perverted cerebral action, derangement of renal secretion, loss of appetite, wasting away, etc. Elimination must take place by the kidneys. Mosetig-Moorhof, its introducer, claims that free elimination by these emunctories is prevented by carbolic acid when carbolized spray or irrigation is used during operation. He, therefore, advises that they be not employed.

With respect to the quantity of the drug that may be safely used, we may say that the limit of safety has been set at 10 Gm., though much more may be tolerated. Gussenbauer has poured 240 Gm. into the cavity left after resection of the ankle, with no unpleasant result.

The penetrating, tell-tale odor of iodoform may at least be partially disguised, when desirable, by balsam of Peru, eucalyptus oil, tonka bean, and various other drugs.

Iodoform may be used in dry powder by dusting through a sprinkler, or by using one of the various forms of powder-blowers. When desirable to introduce it into deep cavities a saturated ethereal solution may be poured in; the ether immediately evaporating leaves it behind in fine powder. We give two formulæ for the preparation of iodoform gauze: Iodoform, 50 Gm.; ether, 250 C.c.; alcohol, 1,000 C.c. This is enough to saturate 500 Gm. by weight of cotton or gauze.

Dissolve 60 Gm. of resin in 1,200 C.c. of alcohol, add 50 C.c. of glycerine; in this immerse 6 metres of gauze, and wring as dry as possible; then dust over it 50 Gm. of powdered iodoform by means of a proper blower. Or if in haste, the dry powder may be simply rubbed into the meshes of dry gauze.

The proper method of dressing wounds such as those left after excision of the tongue, larynx, rectum, kidney, or after pharyngotomy, œsophagotomy, etc., is by iodoform gauze, and not by filling the wound with dry powder. Care must be taken that it lies snugly packed into every corner of the wound, completely filling all pouches and sinuses. Thus *packed* it may be left in the oral cavity six to eight days. It is not irritating, and keeps a wound antiseptic, no matter if saliva, pus, urine, or fæces pass over it. Separate drainage of a wound thus packed is unnecessary. The gauze may even be left in place undisturbed for from five to fifteen days. As soon as the wound granulates nicely, the gauze may be discontinued. Dusting or rubbing in the drug may lead to poisoning; treated as above this accident never occurs, except possibly in the largest wounds.

Mercuric (Bi) Chloride, Corrosive Sublimate.—For the introduction of this drug into general surgery we are indebted to Bergmann, who began to use it in 1878. It now takes rank as our most powerful and reliable antiseptic. One part in 40,000 prevents the development of septic cocci; 1 in 6,500 kills bacteria in broken-down beef-tea; 1 in 10,250 prevents their development; and the spores of anthrax bacilli, the most resistant known, are killed by ten minutes' immersion in a solution of 1 to 1,000.

For ordinary surgical purposes it is used in the proportion of 1 in 1,000 to 2,000. In this strength it is now used in most of the hospitals at home and abroad for every purpose except immersion of the instruments. Sponges and silk are kept, before using, in stronger solutions. For the country practitioner it forms the most portable as well as efficient antiseptic, since powders of one gram (15 grains) of finely powdered sublimate are easily dissolved in one litre (one quart) of warm water, thus forming a solution of 1 to 1,000 strength ready at hand.

Poisoning from these solutions thus used is almost unknown; in rare cases where there is peculiar susceptibility it may happen, but is not likely to be serious, much less fatal.

Dr. R. F. Weir, of New York, has shown that when sublimated dressings (jute, cotton, etc.), are allowed to stand for a long time some of the sublimate is liable to lose a part of its chlorine, being thereby converted into calomel. To prevent this it has been suggested by Gibbs that the solutions in which they are prepared should contain one-half of one per cent. of common salt. Weir has also found that even in solution, allowed to stand for a length of time, sublimate undergoes the same change to a certain extent, judging from the fact that lime-water added to it gives a mixture of black and red precipitates.

Sir Joseph Lister has lately called attention to the remarkable solubility of sublimate in glycerine, three parts taking up two of the dry powder, while it is only soluble in sixteen parts of water. We are thus furnished with a means of carrying a very concentrated solution in small bulk. In this connection, making a reference to military surgery, he showed that rags are really the same material as wood-wool, and that clean rags of any kind could be antisepticized by soaking in a mixture of one part of the above glycerine solution in two hundred parts of water, and then hanging up to dry.

Still more recently (October, 1884), he has delivered an address on the use of sublimate, in which he calls attention to some recent failures with carbolic acid and eucalyptus, owing to their volatility and consequent uncertainty. His only objection to sublimate has been its irritant properties, and these he has succeeded in obviating by combining it with blood-serum, taking advantage of the well-known fact that the inert coagulum which sublimate forms with albumen is soluble in excess of serum, the solution thus probably forming a double albuminate of mercury. This solution possesses all the germicidal properties of its active agent, yet is absolutely non-irritating in any proportion in which it should ever be used. Lister saturates a gauze with a one per cent. preparation, and even applies this to the dry skin. A gauze when so prepared gives off a dust which is slightly irritating to the nostrils, hence it is best to cut it with scissors.

When the prepared serum is placed in water it does not dissolve, but becomes opaque, the albumen retaining nearly all the sublimate. Hence, when perspiration soaks into such a dressing it does not soak out the irritant chemical; the skin is thereby saved from irritation. While time sufficient for a fair trial of this dressing has not yet, at present writing, elapsed, it gives remarkable promise of good; while for all practical surgeons Sir Joseph Lister's own endorsement is amply sufficient to warrant its immediate introduction into practice.

Sublimate gauze, made according to the following for-

mula, will be found an admirable protection and substitute for carbolic gauze:

Corrosive sublimate	20
Glycerin	500
Water	4,480
	5,000

In this is soaked ordinary cheese-cloth, which has been boiled in soda solution to remove its fatty matter, and then washed and dried. Thus prepared, it is perhaps better for external use than any other antiseptic dressing, except that prepared with serum as mentioned above. Absorbent cotton may be rendered antiseptic in the same way; but both should be prepared freshly and not allowed to become old, for reasons already mentioned.

Naphthalin.—A coal-tar product, with the formula $C_{10}H_8$, discovered in 1820 by Garden, and introduced as an antiseptic in surgery in Luecke's Strassburg clinic, by Fischer. A white crystalline body, difficult to reduce to powder, melting at 79° C., insoluble in water, but freely soluble in benzine or in four parts of ether. Bonning, in 1882, made a series of experiments with blue pus, and found that naphthalin quickly destroyed the peculiar fungus which imparts the bluish tint; also that it quickly killed all the rod-shaped bacteria, though an occasional coccus would escape its influence. In doses of 2 to 3 Gm. it had a laxative effect, sometimes causing slight strangury. Stewart, of Montreal, has kept a half pint of urine sweet for three weeks with twenty grains; and not only urine but pus, milk, serum, etc. He claims that it colors the urine, though in this respect he contradicts Bonning.

Naphthalin is an admirable germicide, and has, moreover, properties which make it seem almost specific as against the micro-organisms causing erysipelas. Fischer called attention to this fact soon after beginning its use, and the statements to this effect of various foreign observers have received confirmation in the writer's hands. An ointment containing from five to twelve per cent. of the drug may be smeared over the affected part. It seldom fails to, at least, give relief, and the writer has frequently seen the appearances of the disease quickly fade away under its use; so often, in fact, that he feels justified in recommending this as the most reliable treatment of the many he has tried. The same ointment will be found very useful in various parasitic and other skin diseases.

A common formula abroad for the preparation of naphthalin gauze or cotton, is to soak the material in the following: Naphthalin, 1 pint; ether, 4 pints; alcohol, 12 pints. Thus prepared, it costs very much less than iodoform gauze or cotton. A still cheaper way, devised by the writer, is to prepare cheese-cloth so as to make it absorbent, by boiling in alkaline water, and then, after drying, to let it take up a saturated solution of naphthalin in benzine or gasolene, after which it is hung out on a line so that the very volatile solvent may evaporate. The gauze must then be kept in air-tight jars or receptacles, since the naphthalin itself is very liable to gradually evaporate.

Though slightly irritating to a delicate skin, and rendering the use of protective advisable, naphthalin will be found a very reliable antiseptic. Sluggish ulcers are quickly stimulated by it into healthy activity; to them it is applied in fine, dry powder. For many purposes it is enough to simply sprinkle this powder into cotton or cheese-cloth for outside dressings. Djakonow, Doutrelepont, and Delhougne, among other foreign observers, speak most highly of it, while in this country it has been particularly introduced, used, and commended by Fowler, of Brooklyn, and by the writer.

Peroxide of Hydrogen; Oxygenated Water.—Péan and Baldy have used water impregnated with two to six volumes of oxygen, partly as an injection in cystic trouble, ozæna, etc., and partly internally (3.0 to 5.01 Gm. in 150 C.c. water) in uræmia, septicæmia, erysipelas, diabetes, tuberculosis, etc. They have also used it locally, compresses being wet with it, covered with some impermeable protective, and renewed when dry; also for irrigation and in the spray. They have expressed themselves well pleased during these trials, but it is hardly likely that in their efforts they will find many imitators in this country.

Potassium permanganate has but a limited range of antiseptic usefulness. A two per cent. solution destroys the virulence of septicæmic blood. Cocci of pus are killed by 1 in 800; 1 in 300 prevents the development of bacteria, while those in broken-down beef-tea are killed by 1 in 35.

Resorcin.—Melts at 118° C. and sublimes at 276° C.; is soluble in water and alcohol. Solutions of one-half to one and one-half per cent. can be used in spray, the latter strength having well-marked antizymotic properties. A five per cent. solution may be used in the bladder in cases of cystitis, while alcoholic solutions with a small proportion of glycerine serve for the preparation of gauze and cotton. Reasonably efficient, but rarely used.

Salicylic acid has the advantage over carbolic acid that neither in strong solution nor in powder has it odor nor caustic effect; its disadvantages are its slight solubility in water and the fact that its powder is irritating to the nose and fauces. By the addition of borax it is made more soluble; such a solution of two per cent. strength kills bacteria in decomposed beef-tea, while by itself 1 in 1,121 prevents their development. The solutions of 1 in 300, so often employed, are, nevertheless, too weak to trust for purposes of irrigation where carbolic acid is irritating or obnoxious; a 1 to 100 solution, made by aid of borax, should be used.

It was brought into surgical use by Thiersch, of Leipzig, and has been used a great deal. In the spray it is non-irritating to serous membranes. Volkmann has showed that in those cases where the discharges have a sour odor, and sphæro-organisms are found under the microscope, the use of the acid checks all mischief and destroys the odor. Lister makes a cream or ointment of salicylic acid for application around the edge of other dressings where irritation has been set up. Dusted in powder on ulcerated surfaces it dries into a crust and forms a protection from the air. Three and ten per cent. salicylic cotton are kept by the dealers, or may be easily made, and are very efficient substitutes for the carbolic gauze.

Sugar.—In May, 1883, Luecke and his assistants began experimenting in the Strassburg clinic with sugar, using it not only pure but mixed in equal proportion with naphthalin, and also in combination with one-fifth of iodoform. These mixtures were made up in gauze bags, laid over the wound or directly on the raw surface, and covered with the usual outside dressings. They were allowed to remain eight to fourteen days, and proved very absorbent. The bags should not have a thickness of more than half a centimetre, otherwise there is a tendency to the formation of lumps.

Under these dressings there was no odor, the parts invariably appeared well, and bacteria could never be found in the moisture or discharge. Granulations proceeded healthily and satisfactorily, and were not too vascular; where it was possible union *per primam* always occurred. They therefore recommend it as a most cheap and efficient dressing.

The writer had been using it, both in surgery and in the preparation of anatomical specimens, independently and ignorantly of these experiments, when their results were published, and publication of his own work thereby rendered of less interest, and consequently postponed; his conclusions, however, independently arrived at, were to the same effect.

In this connection it may be well to call attention to the fact that Galen said of sugar and honey that they would prevent putrefaction (which of course their daily domestic use amply proves); and that Avicenna used them in the treatment of ulcers. The Turks wash wounds twice a day with wine and then cover them with sugar. Lastly, it will be remembered that during our Civil War Packard found sugar to be the best application in cases of hospital gangrene.

Thymol was brought to the notice of surgeons by

Volkmann and Ranke, of Halle. An alcoholic solution of 1 in 20 kills bacteria in broken-down beef-tea; 1 in 1,340 prevents their development. At first it promised well, but it has not stood exhaustive tests, and is now seldom or never used, except in washing out thoracic or pulmonary cavities, and in the spray during laparotomy, when the solution should be at least 1 in 250, instead of 1 in 2,000 as at one time recommended.

Trichlorphenol.—Discovered by Lamont in 1836; introduced into Russian surgical practice as an antiseptic by Pelechin in 1879, and his recommendation warmly emphasized by Dianin. Aside from its general uses, Popoff has recommended a five per cent. glycerine solution to be painted over the affected surface in cases of erysipelas, saying that two or three applications check the disease. In eight cases reported he had surprising results. He also uses a 0.06 per cent. solution for injection in leucorrhœa, gonorrhœa, etc., and for a local spray upon laryngeal ulcers.

Zinc chloride was recommended in 1866 by De Morgan. Lister uses an eight per cent. solution for disinfection of sinuses, fistulæ, and sloughing surfaces. A solution of 1 to 50 kills the gonococcus; 1 in 200 prevents the development of septic cocci. According to Hack a surface to which a strong solution has been applied is almost incapable of absorption.

Recently Kocher has published his experience with the use of weak solutions in the Berne clinic. He has found even 0.02 per cent. solutions very satisfactory; he also saturates his dressings with the same or stronger ones. Bardeleben has used cotton, gauze, jute, etc., prepared with ten per cent. solutions; and especially commends them for the fact that their antiseptic is not lost by evaporation nor changed by exposure.

If we choose, in closing the consideration of particular antiseptics, we may select the six most commonly used in this country, and, abstracting the following figures from Sternberg's tables, present the following tabular estimate of their relative germicidal power:

	Per cent. required to destroy vitality.	Per cent. required to prevent development.
Corrosive sublimate	0.005	0.003
Iodine	0.2	0.025
Carbolic acid	0.8	0.2
Salicylic acid	4.0	0.05
Boric acid	4.0	0.05
Alcohol	40.0	10.0

Aside from drugs, we have yet to consider dressing materials which may be impregnated with them, and antisepticized suture and ligature materials.

By boiling in carbolic or in sublimate solutions, both silk and hempen thread may be rendered thoroughly aseptic. If the former is used it should be of the strength of 1 to 20 or 30. If the latter, a one-half per cent. solution. Boiling should be continued for half an hour. After this the material should be kept on spools submerged in similar but weaker solutions. Silk thus prepared and kept may be used for any internal purpose, cut short and left, without fear that it will cause any untoward irritation.

We have already learned that carbolized oil is in nowise to be depended on, hence catgut preserved in it is unreliable. With trifling trouble every one may prepare catgut for himself at small cost, and with a certainty that it will be aseptic; the method is known as Kocher's. Raw catgut of desired sizes is procured of wholesale jewellers, or other dealers, sizes 0, 1, and 2 being most desirable; if it seem greasy or smell at all badly it may be immersed in ether or benzine, which will dissolve out the fatty matters. It is then immersed in oil of juniper *berries* (not wood), in which it is allowed to remain two or three days. It is now only necessary to put it into alcohol containing 1 to 1,000 of sublimate, which bleaches it out, and in which it is to remain until wanted for use. By this method it is not only rendered aseptic, but is hardened so that it may be depended on not to be absorbed too quickly.

With regard to silkworm-gut, ox-aorta ligature, kangaroo-tendon, and the like, while they are not in general use, if desired they may also be prepared according to Kocher's method.

Neuber's decalcified drainage-tubes had best also receive similar treatment, that asepsis may be insured. When rubber drainage-tubing is used, it also should be kept in a jar, submerged in a 1 to 500 to 1,000 watery sublimate solution.

Coming now to absorbent dressings, the market is stocked with numerous brands of absorbent and prepared cottons (boric, salicylic, iodoform, sublimate), jute (similarly prepared), peat, glass-wool, wood-wool, wood-flour, oakum, etc. Besides these, various other cheaper or more domestic materials can be procured and efficiently prepared.

Sawdust, for instance, which is quite absorbent, may be nearly parched by baking, and then soaked in a 1 in 200 sublimate solution, dried, kept in a tight box or jar (but not too long), and filled into gauze bags as desired for use. Symonds recommends the soaking of coarse sawdust, which is better than fine, in wine spirit containing ten per cent. of phenol (carbolic acid), after soaking it is exposed to the air till the alcohol has evaporated, when it is kept in tight receptacles. This, too, is enclosed in bags of several layers of prepared gauze, placed outside the deep dressing, and covered with impervious tissue.

Flax.—Following a recommendation of Mededew, a Russian lady physician, Makuschina by name, has shown how flax of good quality can be very cheaply prepared. It is boiled for three hours in a wood-ash lye, and soaked therein for eight hours longer, then dried and combed out. By this process it loses twenty to twenty-five per cent. of its weight and becomes soft, white, and absorbent. Instead of lye a two per cent. soda solution may be used. In Russia, as thus prepared, it costs only one-fifth as much as a cotton or gauze dressing. It may then be prepared with any antiseptic desired.

Wood-wool and *wood-flour*, the latter the finest, are made from pine wood; they are very soft and absorbent. They are best prepared with one-half per cent. by weight each of sublimate and glycerine; and when used are made up in gauze bags of desired size and thickness.

With regard to relative absorbent powers, it is said that cheese-cloth absorbs three times its weight of fluid; moss, four times; sawdust, four times; wood-wool, ten times; jute, eight times; dry punk, eleven times; German peat, twelve times; wood-flour, fourteen times; absorbent cotton, sixteen times.

Moss.—It has been suggested to utilize the soft mosses found in various districts as a dressing material. They should be prepared like sawdust.

Peat.—The peat, originally introduced into the Kiel clinic by Neuber and Esmarch, is now imported and for sale by dealers in this country. At wholesale it costs sixteen cents a pound, and is as efficient as it is cheap. It comes already prepared with a proper percentage of sublimate, and requires only to be made up in bags of sublimate or naphthalin gauze, slightly dampened (dampening makes it more absorbent), and applied over the deep dressing, with some impervious tissue over it. It has special power to absorb gaseous products of decomposition, *e.g.*, ammonia; hence, according to Hart, when it is employed as a litter for horses, the same beds can be used for two or three months without change.

Sand.—Clean sand may be first baked and then mixed with sublimate in the proportion of one drachm (dissolved in alcohol or ether) to each pound of sand. When this is made up in fine gauze bags it will fulfil certain indications remarkably well.

Glass-wool is a most beautiful dressing material, but its expense will preclude its ever coming into use.

Oakum, being more or less impregnated with tar, is more or less antiseptic, though very slightly absorbent. For a copious outside dressing, or for filling a fracture-box, it will sometimes serve a useful purpose.

It is of the utmost importance that the sponges used during operation or dressing should be *surgically clean;* we therefore give here a ready but effective method of rendering them so. Sponges of fine, even texture

should be selected, and the sand which they contain beaten out with great care. They are washed and soaked for twenty-four hours in a 1 to 1,000 solution of potassic permanganate. Again they are washed in clean water till they fail to soil or discolor it. They are next bleached in a 5 to 500 solution of sodium sulphite, to which is added 1 part of a watery solution of hydrochloric or oxalic acid of a strength of 1 to 12. From this they are removed as soon as bleached, else they become brittle. After a final washing they are to be kept in a 1 to 20 carbolic, or a 1 to 500 sublimate, solution until wanted for use.

After use, if simply blood-stained, they may be cleansed and employed a second time; but if they have taken up any pus or fæcal matter they should be burned. The second cleansing should consist of washing in an alkaline solution till they cease to discolor it, after which they had best go through the permanganate and bleaching solutions again. At all events they should soak for two weeks in the usual antiseptic solution before being again used.

Many a failure in operative surgery has resulted from lack of proper precaution with respect to *clean* sponges; failures which proper oversight and a little care might have prevented.

In order to avoid ever using the same sponge more than once, Gamgee, of Birmingham, has devised a new substitute made of fine fibre of cocoa-nut bark, carefully cleansed and prepared, enclosed with cotton in a sort of gauze cover. In their interior is a very thin glass or gelatine capsule containing some antiseptic, such as eucalyptol; a sharp pinch or a slight blow is sufficient to break this and allow its contents to diffuse through the fibre. These sponges are very absorbent, taking up fifteen times their weight of fluid. They may be impregnated with any desired antiseptic, may be sterilized at high temperatures, and are intended for use only during one operation, after which they are burned.

Lastly, we should be doing but scant justice to the subject did we fail to give at least a little space to the consideration of

ANTISEPTICS ON THE BATTLE-FIELD AND IN MILITARY SERVICE.—We have already seen that the exacting details of the Lister system are by no means requisite to an antiseptic dressing. They are only one means to an end which may be in other ways attained. This part of the subject has to do largely with the treatment of gunshot wounds, and this, as is maintained by those best able to judge, should be by primary antiseptic occlusion (*vide Annals of Anat. and Surg.*, February, 1883, p. 114). That granted, the question resolves itself into this: How can it best be performed? And the most perfect solution yet arrived at has been reached by the Continental military surgeons.

Fig. 198 represents Esmarch's first dressing for the wounded in battle. No. 1 is the packet folded up, to be carried in the soldier's pocket, and containing, No. 2, a triangular bandage whose numerous possible uses are pictorially represented upon it; No. 3, a gauze bandage (antisepticized); No. 4, an antiseptic tampon, and No. 5, an ordinary tampon and square of oiled paper.

Each soldier is so instructed that he, or a comrade for him, is prepared to make this occlusion immediately after reception of a wound. By such means many a valuable life is saved, in that its loss from sepsis is prevented.*

At a meeting of the Woolwich Military Medical Society held in February, 1884, Sir Joseph Lister made some most important remarks concerning the application of antiseptic dressings on the battle-field and in campaigning. He showed that it is of no use for one surgeon to treat a patient antiseptically if the one who has preceded or who is to succeed does not do the same. In this respect he followed Reyher, who divided his cases into the *fingered* and the *unfingered*. He (Reyher) had happened to have fourteen cases of gun-shot wound of the knee-joint, seven belonging in each class. Six of the fingered cases died, while all of the unfingered recovered, and only one had any fever. Results like these speak most eloquently for primary antiseptic occlusion. It was at this meeting that he called attention to the great solubility of sublimate in glycerin (*vide* Mercuric Bichloride, above), and he thought that we must place our main reliance for military purposes in preparations containing either sublimate or iodoform.

At the same meeting Surgeon-Major Stevenson claimed that while typically perfect asepsis on the field was impossible, we yet ought to be as antiseptic as we may. As there is sure to be more or less dirt around a soldier's wound, and as washing materials are not to be had on the battle-ground, he suggested pads, coated on one side with a wax saturated, say, with eucalyptus or something of the kind; when applied, the wax melts at body-heat, and the skin is then protected or bathed in an antiseptic. For this purpose he particularly commended spongiopiline.

Lesser, of Leipzig, has suggested that every soldier carry a cartridge emptied of its powder and bullet, and

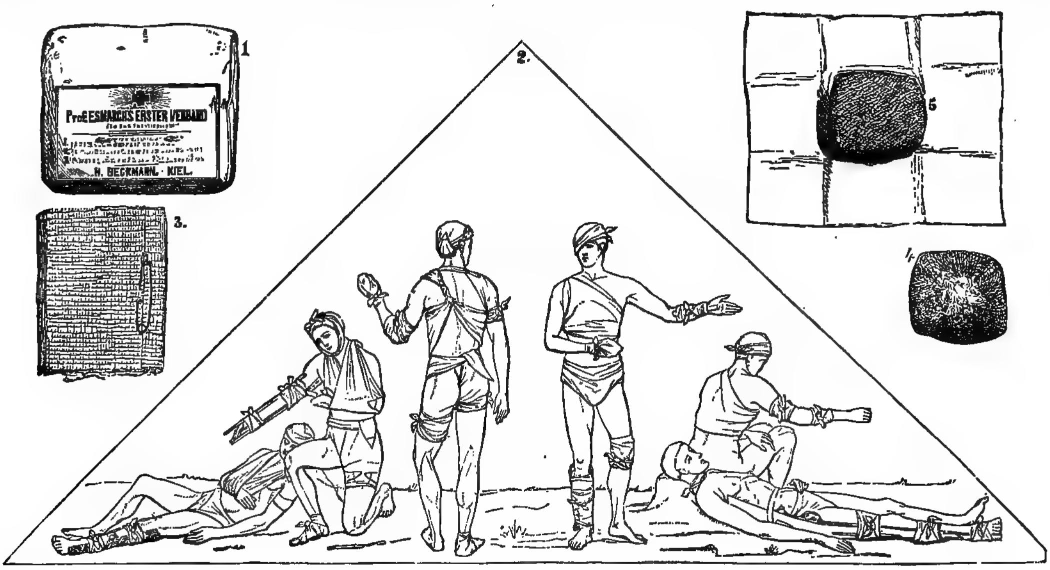


FIG. 198. (From MacCormac.)

* The great advantage of providing American police officers with similar packets, and instructing them in their use, will be apparent to every one.

filled with a mixture of boric acid and iodoform, or some good substitute.

More recently, at the Copenhagen International Medical Congress (1884), Esmarch laid down certain rules for action in the service, which we summarize as follows: 1. Humanity demands antiseptic treatment of the wounded. 2. All military surgeons should know every detail of such treatment, and all hospital assistants and bearers of the sick and wounded should know its general principles. 3. Every soldier should carry some form of bandage which may be used at least as a provisional protection. Such material must be compact as possible. 4. Sublimate, being the best antiseptic, must be used in the dressing. 5. From a dressing impregnated with it, squares can be cut which can be folded into small shape for small wounds, or several thicknesses can be used for large ones. 6. From this material also bandages can be made. 7. Such carbolic acid as may be needed may be carried in crystals, or in vessels of known measure, so that proper proportions may be easily attained on dissolving it. The spray, protective, and mackintosh, may be quite dispensed with on the field. 8. In case the dressing materials be all used up, the assistants should be familiar with the preparation of wadding, jute, lint, turf (peat), sawdust, etc.; and to this end strong glycerine solutions of sublimate should be carried. 9. While iodoform in powder is indispensable for certain purposes, it is inferior to sublimate for general use. 10. Sublimated catgut and drainage-tubes of suitable size must be ever at hand. (Fig. 199 represents a most convenient receptacle intended for this purpose, and made to stand rough handling.) 11. Sponges should not be employed; some substitute should be used and then destroyed. 12. Instruments should not have furrowed handles or parts; such tend to harbor germs and are not easily cleaned. 13. When, owing to the exigencies of the case, a strict antiseptic dressing cannot be applied, the rule should at least be "Do no harm." 14. Keep out of the wound all fingers and instruments not surgically clean. The only exception to be made to this rule is in case of sudden and dangerous hæmorrhage. 15. Bullets must never be extracted without antiseptic precautions. 16. Surgeons at the temporary dressing-places who have no adequate antiseptic facilities must abstain from operation, contenting themselves with a provisional protective dressing, with application of splints, etc. 17. After arrival at a field-hospital of a case so protected, if no such symptoms as pain, fever, or suppuration make it necessary to change it, the first occlusive dressing should be left untouched. 18. If, however, examination should prove necessary, then the first dressing must be removed and energetic antiseptic measures instituted, along with drainage and thorough disinfection. 19. Only in cases where no medical help is at hand, should soldiers themselves apply the bandage and dressing they carry. This triangular bandage (see Fig. 198), is an essential of each soldier's outfit.

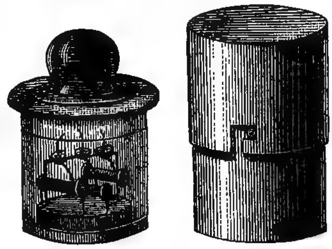


FIG. 199. (From Fischer.)

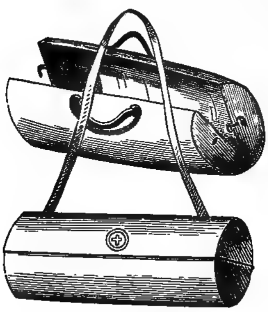


FIG. 200.

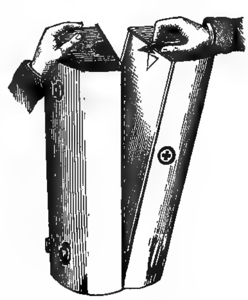


FIG. 201.

To these admirable aphorisms the writer would only add an appeal that their practical application be extended to all gunshot wounds in civil practice. Time and again he has seen in private and hospital practice the disastrous results of miscellaneous and ignorant interference when all that was required was the simplest primary antiseptic occlusion.

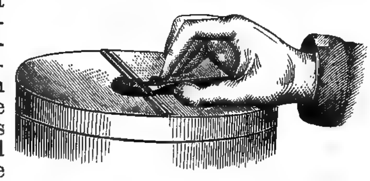


FIG. 202.

To these remarks the writer desires to append a description of an antiseptic dressing-case made by the International Bandage-Material Factory of Schaffhausen, in Switzerland. As originally made it is intended to supply a portable means of making a perfect Lister dressing; but it requires only a slight change of contents to adapt it to any desired antiseptic purpose. It is a model of compactness and ingenuity. Fig. 200 shows an outside case into which the whole fits, with a strap by which it may be slung over the shoulder. Fig. 201 shows the two portions of which it is composed, made of copper, and enamelled wherever fluids come into contact with it. They close together and are separated as seen in the cut, being fastened when closed by a spring-catch, shown in Fig. 202. One half forms the basin, seen in Fig. 203; the other the irrigator, shown in Fig. 204. The purposes of the basin suggest themselves. The irrigator is so graduated that a carbolic or sublimate solution of known strength can be mixed with any desired proportion of water. Beneath it is a place for a tube, which can be coiled up out of the way as desired, can be made to serve as a simple irrigator-tube, or can be combined with the bulb and rubber spray-tube (carried inside it when not in use), and made to give both spray and irrigating stream.

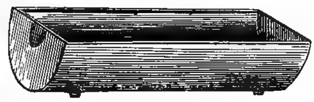


FIG. 203.

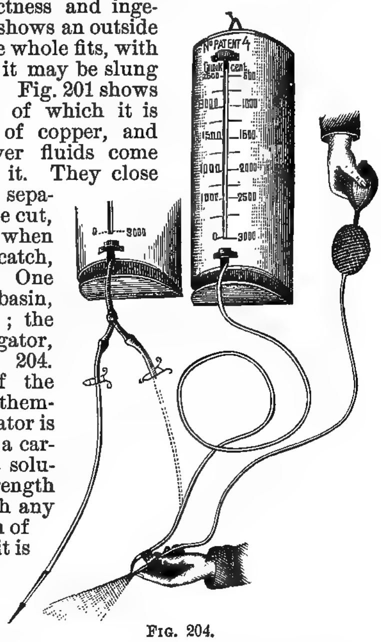


FIG. 204.

Fig. 205 shows two pasteboard-boxes, made of suitable size and shape, so that they fit into their respective metal parts. They are lifted out when the apparatus is in use. They contain enough dressing materials for one or two cases without replenishing, such as bottles containing drainage-tubing in carbolized water, catgut in suitable solution, strong carbolic acid (or glycerine sublimate solution) in graduated bottles, to be diluted in the irrigator, shown in Fig. 204, to suitable strength; sponges or their

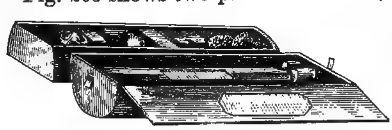


FIG. 205.

substitutes, bandages, gauze, antiseptic cotton, protective, mackintosh—everything, in fact, which can be needed. These may be replenished as fast as used. A bottle for chloroform and a hypodermic syringe may be added if desired.

For the army medical officer, as for the railroad or police-surgeon, the case furnishes literally *multum in parvo.*

Roswell Park.

ANTISPASMODICS. This is the somewhat unscientific name given to a class of drugs of which a limited number only are of real therapeutic value. These remedies were supposed to be of special service in controlling attacks of muscular spasm depending upon functional nervous derangement. The inappropriateness of the name is seen from the fact that it is not alone convulsive phenomena which form indications for their use, but that they are also useful in other of the multiform manifestations of nervousness or of hysteria. The theory of their mode of action—if, indeed, any one method of action is common to all the members usually included in the class—is not sufficiently established to made any discussion of it profitable in this place. Suffice it to say that it is not impossible that, at least, one important action of these drugs is a local one upon the intestinal tract, where their warming and stimulating character may produce a revulsive effect. For the detailed description of the most important drugs included under this heading the reader is referred to their proper titles.

Of the different remedies known as antispasmodics, we mention first a group of animal origin, strongly odorous, but of little therapeutic value. *Moschus*, musk, an oily substance obtained from the preputial glands of the Thibetan musk-deer, is the only one of this class which is used to any extent. In the last stages of adynamic diseases, as typhoid fever, it is given, especially by German physicians, but rather as a forlorn hope than with real confidence. Its former use in hysteria is now quite superseded. *Castoreum*, a corresponding secretion from the *Castor fiber*, or beaver; *ambergris*, a morbid product obtained from the sperm-whale, and the source of the *oleum succini;* and the *oleum animale* of Dippel, a substance of disgusting origin and nature, obtained from "trying out" decomposing animal structures, deserve mention only as having been at some time used as antispasmodics.

Another group consists of drugs of generally feeble action, but occasionally useful in infantile hysteria and allied states. Among these are *humulus*, hops, and its derivative, *lupulin*. The former, applied locally in the form of poultices or embrocations, has possibly some virtue, and the latter is somewhat more active internally. *Lactucarium*, derived from the garden lettuce, is even more feeble than hops, but as some persons are made drowsy by eating lettuce, it is not impossible that lactucarium may have in certain cases a useful medicinal effect. The claims which have been made for *celery* as an antispasmodic and anticephalalgic do not seem to rest on reliable grounds. *Cimicifuga*, or black snakeroot, belongs in this group. It has been chiefly used in chorea, and in full doses it has seemed to have some effect. *Dracontium*, the root of the "skunk-cabbage," and *Galbanum*, an ingredient with asafœtida and myrrh in the *Pilula Galbani Comp.*, U. S., have also had antispasmodic virtues ascribed to them, but with little reason.

We now come to the group which contains the most important drugs of this class. They are three in number, viz.: *Camphor, valerian,* and *asafœtida.* They all produce a sensation of warmth in the stomach, and probably stimulate the whole alimentary canal. But that this is not their sole action is proved by their superiority in certain nervous states over the essential oils and other so-called carminatives. The intestinal action of camphor makes that drug a valuable aid in the treatment of cholera and choleraic diarrhœa. In the delirium of adynamic fevers and as a sedative for "nervousness" it is useful. An especially quieting influence has been claimed for it in sexual irritation and excitement. For more distinctively hysterical symptoms, camphor is often combined with bromine in the form of bromated or monobromated camphor, which, despite its disagreeable taste, difficult solubility, and frequent tendency to cause irritation of the stomach, is considerably used for chorea, reflex convulsions, etc. Perhaps no drug is more generally used to combat the true hysterical convulsive seizure than *valerian*, and certainly in many cases it meets the indication better than almost any other agent. The fluid extract and the ammoniated tincture are among the most eligible palliatives of the hysteric attacks, sometimes a single dose serving to restore consciousness. For more protracted use in the countless nervous manifestations of hysteria, hypochondria, and neurasthenia, the salts of valerianic acid, notably the valerianates of zinc and of ammonium are especially adapted, serving to control at times even such positive and conspicuous symptoms as neuralgia.

Asafœtida, long the synonym for what is most loathsome and offensive to the palate, acts very like valerian in the hysteric attack. The flatus which has been rolling about in the intestine is expelled, and, as has been intimated above, there is some reason to believe that the stimulation of the intestinal mucous membrane and the revulsion so caused may, with the relief of the tympanites, play a prominent part in the alleviation of the hysterical spasm. In cases where simulation seems to have any part in the attack, the vile taste of the drug may become of service in adding to its effectiveness. In other cases we may give the drug by enema, and its action upon the intestine and also its effect on the convulsions will be nearly the same as if it were administered by the mouth.

While the above-mentioned drugs constitute the more distinctive antispasmodics, there yet remain two groups to which the term is often applied, and of which some part of the action is similar to that above described. The *compound spirit of ether*, Hoffman's anodyne, is very useful in controlling nervous disturbances, as is also the *spirit of chloroform*, formerly known as chloric ether. The substances from which these are derived—sulphuric ether and chloroform—may, administered internally in appropriate doses, be employed for the same purpose, although, of course, their more proper classification is among the anæsthetics. The *bromides* of *potassium, ammonium,* and *sodium*, though in their most prominent action depresso-motors, are yet, in moderate doses, especially the sodium and ammonium salts, used as antispasmodics.

Finally, we have the group which includes coffee, tea, maté, and guarana, of all which the active principle is practically identical with caffeine. Leaving out of account the important action of this substance upon the heart and circulatory system, and limiting our attention entirely to functional nervous phenomena, we find that in migraine, which in the family of diseases is not distant of kin from hysteria, some of the most useful remedies are caffeine and guarana.

Charles F. Withington.

ANTISUDORIFICS. Remedies employed in the treatment of hyperidrosis, either local or general. The most important drugs in this class are: Alcohol, alum, dilute acids, ergot, belladonna, gallic acid, hyoscyamus, oxide of zinc, sulphate of iron, arseniate of iron, picrotoxin, muscarin, and tonics.

In the treatment of local sweating, vinegar, alum, alcohol, and astringent solutions are chiefly to be relied upon. Excessive general sweating is most frequently due to debility, and hence cod-liver oil, iron, and the tonics in general are indicated. But there are many cases, as in the night-sweats of phthisis, in which tonics are of little avail, and recourse must then be had to agents which exert a special control over this secretion. All of the drugs above-mentioned have been tried for the relief of this distressing condition, and there is none which has been more frequently employed and has proven more uniformly successful than belladonna or atropine. The sulphate of atropine may be given either by the mouth or

subcutaneously, but care should be observed in its use, as patients suffering from phthisis seem to be especially susceptible to the cerebral effects of this drug, and instances have occurred in which wild delirium followed the ingestion of a very moderate dose. Picrotoxin has recently been very highly recommended by Dr. Morrell in the treatment of the night-sweats of phthisis. It is given in doses of one-sixtieth of a grain (0.001 Gm.). Muscarin has also been said to control night-sweats when given hypodermically in five-minim (0.3 Gm.) doses of the one per cent. solution. Oxide of zinc and the iron salts have enjoyed considerable reputation in this condition, but they are usually given in combination with belladonna, and it is questionable how far they act as synergists of the latter drug. In the excessive sweating, especially at night, from which corpulent individuals often suffer, aromatic sulphuric acid is probably the best remedy. In the hyperidrosis of debility, while waiting for the effects of the tonic remedies to manifest themselves, we may with advantage give ergot or sulphuric acid, preferably the latter, if its too long continuance do not disturb the digestive functions. Sponging the body with dilute alcohol or acidulated water is also useful. *Thomas L. Stedman.*

ANUS AND RECTUM, Diseases of. From the fact that the lower four inches of the rectum may be both seen and felt in every part, the diagnosis of its diseases becomes comparatively an easy matter, provided only that the proper means be used. With the experienced examiner the sense of touch comes, after a time, to supersede that of sight, and the great majority of rectal troubles are diagnosticated by mere digital examination without the use of a speculum. The symptomatology, moreover, may be of great value, and before proceeding to make the physical examination which is inevitable, certain questions and answers may give the surgeon a pretty clear idea of what he is to find. There is a train of symptoms common to almost all diseases of this part, and which infallibly points to trouble of some kind, though they may not tell the exact nature of that trouble. These are pain, protrusion, hæmorrhage, and discharge. Each of these should be carefully inquired into, but they should not be trusted to alone for the diagnosis. Pain may mean almost anything. Protrusion may be either piles or polypus. Hæmorrhage may denote fissure, piles, or cancer. What the patient describes as mucous discharge with diarrhœa and tenesmus may be ulceration, or it may be an overloaded rectum. For this reason the practitioner who attempts to treat a case of rectal disease without first making a direct physical examination simply commits an act of folly.

How, then, to make a rectal examination which shall be thorough and yet as free from pain as possible? For this there are three things absolutely necessary—a good table, a good light, and a water-closet in connection with the examining-room. Any strong table, or any of the elaborate gynecological chairs will answer the purpose; and either sunlight or artificial light may be used. The patient, male or female, should first be placed in Sims's position, and the skin around the anus, with the anus itself, should first be carefully inspected. In this way, pruritus, external hæmorrhoids, fissure, and fistula may be seen at a glance. An enema of warm water should then be administered through a long tube which will reach into the sigmoid flexure. This should be as copious as the patient can bear without suffering, should be retained as long as can be with comfort, and then passed at the adjacent closet, the patient being instructed to strain well and bring down whatever may be in the habit of protruding at stool. From the closet the patient steps back upon the table, and places himself in the same position, and if there be any internal hæmorrhoids or polypus sufficiently developed to protrude from the anus, they may be seen, especially with the aid of a little more bearing down. In this way sufficient disease may have been found to account for all of the symptoms complained of, but all this has simply been preparatory to the digital examination of the rectum proper, without which no examination can be considered at all complete. The left index-finger should be used when the patient is on the right side, and *vice versa*. It should be well oiled with a tenacious lubricant, and slowly introduced through the sphincter. Force is unnecessary and painful. The sphincter will yield to time and gentle pressure when it will spasmodically resist a forcible attack. The condition of the sphincter should be noted, whether forcibly contracted, unduly dilated, or normal. The former condition may be diagnostic, and may end the examination, for a strong man may scream with agony at a simple attempt to pass the finger, the diagnosis being spasm of the sphincter muscle.

Unless an obstruction is encountered the finger may be carried up the bowel its full length and pressed as far as possible beyond, the patient at the same time being urged to assist the examiner by straining down. Additional distance may be gained by passing the three remaining fingers backward along the inter-gluteal groove, instead of closing them in the palm and pressing the knuckles against the soft parts, as is generally done; for the knuckles prevent the full passage of the index-finger. It is well to know that still another inch may be gained by having the patient stand up and strain down upon the finger in the bowel. In this way four inches of the rectum may be explored with the parts adjacent—the prostate, uterus, neck of the bladder, and anterior surface of the sacrum. With an exceptionally long finger it may be possible to feel the vesiculæ seminales and vasa deferentia. In other words, all that part of the bowel which is most subject to disease is brought within reach, and after the examiner has become thoroughly conversant with the feel of the healthy bowel, any pathological changes may be detected. A stricture of small calibre cannot be mistaken, though one which allows the finger to pass may easily be overlooked. A stricture small enough firmly to engage the end of the index-finger marks the limit of safe digital examination, and the finger should not be forced through it to feel what is beyond, lest a fatal laceration be caused. Ulceration is more difficult to detect, especially when superficial and not attended by much induration; and so is the opening of a blind internal fistula, unless it be large and patulous. Hæmorrhoids, when soft, are easily mistaken for the natural folds of mucous membrane, especially when the latter is lax and gathered into folds. In case of a tumor of any kind, conjoined manipulation should be taken advantage of in the female. The cervix or fundus of the uterus may easily be felt per rectum, and often gives rise to errors in diagnosis.

In case all this has been done and nothing found to account for the symptoms, what remains? The case is evidently obscure, the examiner is still in the dark, and the certainty which comes from actual touch and vision gives place to more or less uncertain inference. There are yet two things to be done. The first is to examine carefully the left iliac fossa for cancer of the sigmoid flexure; the second is to pass the bougie, and try and eliminate stricture high up. If a full-sized bougie be passed twelve inches, and no new growth can be felt by abdominal palpation, cancer may be eliminated with an approach to certainty, though ulceration cannot be. The bougie should be as flexible as possible, should be blunt and perforated, to allow of the injection of water through it. In passing the bougie place the patient on the left side, oil the instrument well, pass it gently till it meets an obstruction, then attach a syringe and fill the rectum with water till it is moderately distended. Then, by gentle pressure, try and urge the instrument farther, and, if unsuccessful, and the patient will bear it, inject more water. By this manœuvre it can generally be passed. If it be not passed on the first trial, it may be after a few days, and a diagnosis of stricture high up should not be made because the end of a bougie persists in catching on the promontory of the sacrum or in a fold of mucous membrane.

If the diagnosis still be doubtful, there is but one means left—ether. Narcotize the patient fully, gently dilate the sphincter till the anus is perfectly patulous, pass the hand into the rectum as far as possible (up to the wrist if it be small enough to enter between the tuber-

osities), and carry one or two fingers up into the sigmoid flexure. This is not a dangerous proceeding with a small hand, and differs essentially from trying to force the whole hand into the sigmoid flexure, which is decidedly dangerous and seldom justifiable; for the narrowest part of the bowel is at the junction of the rectum with the sigmoid flexure, at the duplicature of the peritoneum, and an attempt to pass this point with the whole hand may cause fatal rupture, while one or two fingers may be passed with safety.

It will be observed that nothing has been said about the speculum, and this is for the reason that the speculum is properly an aid to treatment, and is of little use for diagnosis. It is useful in operations, and in manipulation, but it is safe to say that if a diagnosis cannot be made without it, it will seldom be made by means of it. To use it properly, the patient must be etherized and the sphincter must be stretched. Under these circumstances no speculum is as good as Helmuth's modification of Sims's, and by it the whole rectal pouch may be thoroughly thrown open. For office work, without ether, I have had made the one shown in the cut (Fig. 206). It is not for diagnosis, but simply for exposing a certain limited portion of the bowel, such, for example, as a spot of ulceration which needs a local application. Its advantage is that it gives the best possible field of view with the least possible amount of pain, caused by stretching the sphincter.

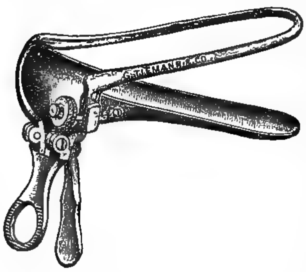


FIG. 206.—Kelsey's Speculum.

HÆMORRHOIDS.—These may be divided into external and internal. An external hæmorrhoid is one situated at the margin of the anus, which does not arise within the sphincter, is always outside of the body, and cannot be made to remain within the rectum, and which arises from the external hæmorrhoidal veins. They present themselves in two perfectly distinct forms, which must not be confounded with each other. The first is shown in Fig. 207, and is a venous tumor, produced by the rupture of an external hæmorrhoidal vein and the extravasation of its contents. Such a tumor forms suddenly, is exquisitely painful, and sometimes looks and feels like a large black grape, or a large pea. It may result from straining at stool, or it may follow a night spent in sociability over a bottle. It is amply sufficient to incapacitate the sufferer from all active exercise while in its acute stage, and it will slowly subside and disappear when treated by rest in bed and applications of powdered ice in a rubber *baudruche*, with the internal administration of a saline cathartic. The most appropriate treatment, however, is a free incision with a small, sharp-pointed, curved bistoury, the tumor being transfixed and incised in the direction of the radiating folds of the anus. As a result of the incision, a small, round clot may be turned out of its bed, the pressure of which has caused all the suffering. In case of a continuous oozing of blood from the sac after such an incision, the best treatment is firm pressure with a compress and T-bandage.

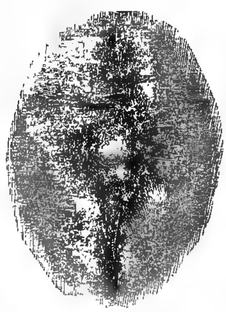


FIG. 207.—External Venous Hæmorrhoid. (Smith.)

The other form of external hæmorrhoid is a cutaneous and not a venous tumor, and is well shown in Fig. 208. This is often spoken of as a condyloma, but that name is better applied to another condition. Such a tumor as this is composed of skin and connective-tissue. It often results directly from the irritation caused by the first variety, and is, in fact, the remains of the venous tumor; or it may be caused by the irritation of some ulcerative disease within the rectum. It is not painful unless it happens to become acutely inflamed, and is generally best left alone. When operating for more serious trouble, with the patient under ether, I occasionally snip them off with a pair of scissors, but when a patient applies for relief from them alone, I usually advise non-interference. The wound made by removing them is painful and they generally do little harm.

Internal hæmorrhoids are those which arise within the sphincter muscle from the internal hæmorrhoidal vessels. They present many variations in structure. One perfectly distinct variety is known as the capillary. This is in reality an erectile tumor composed of the terminal branches of the arteries and veins, and of the dilated capillaries which unite them. This form of tumor is never of large size, and never projects far into the cavity of the rectum. It is, in fact, much like a nævus of the scalp. It may be situated high up in the rectum, but is generally near the anus; the surface is granular, and the membrane covering the vessels is so thin that it may be broken by each act of defecation. Such a tumor never appears outside of the anus unless the protrusion is caused by some other affection, but it may be seen by carefully pulling open the parts with the fingers, and from some part of its mulberry-like surface there is apt to be a jet of arterial blood, coming *per saltem*. This is, above all others, what is most properly called the "bleeding pile." It is not as frequently met with as the varieties next to be described, and it is probable that, after existing for a longer or shorter time in this form, the mucous membrane covering it becomes thickened, there is an increase in connective-tissue, the hæmorrhage decreases in frequency as the capillaries are closed up, and finally, the capillary tumor is succeeded by an arterial or venous one.

FIG. 208.—External Cutaneous Hæmorrhoids. (Esmarch.)

This form of hæmorrhoid may be cured by a single thorough application of fuming nitric acid, and it is the only form in which this plan of treatment is likely to be of permanent benefit.

In the other forms of hæmorrhoids there is a distinct tumor, sometimes of considerable size, made up of mucous membrane more or less eroded, of connective-tissue, and of blood-vessels. In some the arteries seem to predominate, and in others the veins, and for this reason they have been classified, without much reason, as arterial and venous, but there is little essential difference between them. These tumors may cause decided symptoms before they are sufficiently large to protrude from the anus. One of the first is an unsatisfied feeling after defecation, as though the rectum were not fully emptied; and this is explained by the increase in size of the tumors caused by defecation, and passes away after a few moments when the circulation has again become natural. Other symptoms are pain, more or less obscure, and referred to the loins and thighs, difficulty in micturition, diminished sexual appetite and power, hæmorrhage, and sometimes a peculiar train of nervous symptoms referred to the legs, which will deceive a patient and physician into the belief in commencing ataxia. After the tumors reach a stage which causes them to protrude beyond the sphincter in defecation, the symptoms are well known. In ordinary cases the patient will reduce the tumors himself after each protrusion. They may, however, become strangulated and be entirely beyond the patient's power of manipulation. In such a case, after a period of rest, and after the relief which may follow a spontaneous escape of blood, the hæmorrhoids may return of themselves or be put back by the patient.

If the strangulation be more intense, gangrene may set

Anus and Rectum.

in and a part of the mass may slough, or a portion may suppurate. Under such circumstances there will be great pain, and more or less constitutional disturbance, with fever. The gangrene is very evident to the eye from the greenish or blackish color and fetid odor of the part, and is rather a favorable termination to the trouble, as it generally results in a radical cure.

The treatment of internal hæmorrhoids is both palliative and curative. Should the surgeon be sent for by a patient when his "piles are down," in other words, when he is suffering from either complete or partial strangulation, he has an excellent chance to recommend and perform a radical operation with the ligature, or the clamp and cautery. The operation does not seem to be contraindicated under these circumstances, and I have several times performed it with the happiest results. Should an operation be declined, the mass must be reduced if possible. The patient should be turned on the face, with a hard pillow under the pelvis to raise the buttocks and allow of gravitation of the abdominal viscera away from the rectum. The mass should then be well smeared with olive oil, and a gentle effort made to reduce it by taxis. Much gentleness is required for this manœuvre, which is a very painful one under any circumstances; and one man may succeed where another fails. If the taxis fail, cold should be applied, and the patient left in bed on his face with the buttocks raised. After several hours a second attempt may be made, and should this also fail there is nothing to do but to wait for the condition to subside, under the use of cold and applications of a soft ointment of equal parts of extract of belladonna, and extract of opium, with rest in the position named and the administration of laxatives. After forty-eight hours of this treatment the patient will generally succeed in reducing the mass by himself.

It is a great advantage to the surgeon to know what can be done for a timid patient without anything which may properly be called an operation. The first thing is to secure a daily natural evacuation of the bowels, and this without medicine if possible. The diet should be plain. Highly seasoned dishes, gravies, salads, old cheese, etc., all alcoholic drinks, and any excess in tobacco should be strictly interdicted. If necessary a laxative may be added to the daily diet, and this may be either a glass of mineral water before breakfast, or a drachm of compound licorice powder at night. The local treatment consists mainly in the use of astringents and cold water. A cold sitz-bath every morning after stool is one of the best of all methods of preventing and relieving hæmorrhoids, and cold, or even ice-water, should be freely applied after each passage. The best astringent is the subsulphate of iron in the form of ointment or suppository (ʒ j. to ℥ j. for ointment, and two or three grains in a suppository). By these means, when followed with care and patience, the worst case may be greatly improved. Although they are given simply as palliative measures they will sometimes be followed by such relief as to convince the patient that he is radically cured.

Before recommending anything in the way of a surgical operation, the surgeon must decide whether the case before him is one in which such a procedure is justifiable. A man with enlarged prostate is never a desirable subject for operation, and if such a case can be rendered endurable by palliative treatment it is better not to use the knife. In women, hæmorrhoids often depend upon disease of the uterus, and, if possible, the latter should be cured before an operation is attempted. Pregnancy is not an absolute barrier to operation, though, if possible, the operation is better postponed until a few months after delivery. Hæmorrhoids are often symptomatic of disease of the liver, lungs, heart, or kidneys. There are few liver affections which need prevent operation, provided it is preceded by appropriate general treatment pointing toward relief of the hepatic circulation; and the same may be said of pulmonary disease when not too far advanced. The condition which most positively stays the hand of the operator is albuminuria.

From all the different methods of radically curing hæmorrhoids I shall describe but three. These are the ones which have given the best results, and from them each may choose. By any one of them every case may be cured. The first is the treatment by injection of different fluids, calculated either to cause a sloughing of a part of the tumor, or to set up an amount of inflammation in its substance which shall change its vascular character and cause its gradual subsidence. Of these fluids, carbolic acid in a solution of equal parts of glycerine and water has been found the most satisfactory. It may be used in almost any strength, from one part in thirty to one in three, and it is applied with an ordinary hypodermic syringe, the needle being introduced well into the substance of the tumor. The method requires some practice, and some skill in manipulation in getting a good view of the point to be injected and in making the injection properly; but when this is acquired and the strength of the application is properly regulated, the treatment will be found to give great satisfaction. That by it any case of hæmorrhoids may be cured there is no doubt, and the cure will generally be effected with less suffering and annoyance than by any other method I have ever tried. Many objections have been raised to it, most of them theoretical, and these have kept many from giving it a fair trial. In my own practice it has proved less objectionable than any other plan. It is applicable to all cases; I especially like it in old and bad cases where the tumors are extensive; and often use it where I should not be willing, on account of the patient's general condition, to take the risk of either of the other two operations to be described. I have never known it to fail or to be followed by serious accident.

The treatment by the ligature, as practised by most surgeons at present, consists in cutting through the greater part of the base of the tumor with the scissors, and tying a strong ligature around the remainder, which is supposed to contain the larger blood-vessels. As in all operations on the rectum, the bowels should be thoroughly cleared by a cathartic on the previous day and by an enema just before operating. The patient should be etherized and placed in the lithotomy position, and the sphincter, gently but forcibly dilated till it loses its contractile power. A speculum may or may not be used, as the operator prefers. Each tumor is seized with a long

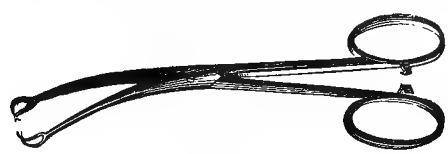


Fig. 209.

toothed forceps, such as is shown in the cut (Fig. 209), and is then drawn out of the anus. Holding the forceps in his left hand, the operator separates the tumor from its attachments, by cutting with a strong pair of scissors in the line of junction of the skin and mucous membrane from below upward until only a pedicle remains. The forceps are then transferred to an assistant, and a strong silk ligature tightly tied around what remains of the tumor, and the hæmorrhoid itself may then be cut off at a short distance from the ligature, to remove as much dead tissue as possible from the rectum. Each hæmorrhoid is thus treated in succession, and after all are removed and the ligatures cut off close, a suppository of opium and belladonna is introduced and a T-bandage tightly applied over a compress of lint and a napkin.

The after-treatment is a matter of a good deal of importance. It is not well to allow the bowels to be confined more than three days, and the first passage should be assisted by a laxative. Much less pain will be caused by a soft passage on the third day after the operation than will result from confining the bowels for ten days or a fortnight as is usually done. Under the latter circumstances the suffering caused by the first passage is often atrocious, and I have once had to break up and remove mechanically a scybalous mass in a lady under these circumstances. The suffering she endured con-

veyed a lesson not to be forgotten. It is not a good plan to try and introduce suppositories into the painful rectum after the operation. There are other ways of administering opium which are much better. The ligatures will generally come away at the end of a week or ten days, and the patient should be kept in the bed or on the lounge for a week longer till the ulcer caused by the separation of the slough has had time to heal. Nothing has been said about primary hæmorrhage. It is sometimes considerable, and there is a good deal of theory about the chief vascular supply of a hæmorrhoid being at the upper end. The incision made with the scissors before the ligature is applied sometimes bleeds very freely, and requires the free use of lint within the bowel after the operation is completed. The removal of this wad is an additional source of pain when its application has been necessary.

This operation, though generally very satisfactory, is subject to certain objections. These are an occasional fatal result, sometimes severe constitutional disturbance with nervous excitement, frequent pulse, loss of sleep, pain sufficient to demand the use of morphine for days, and obstinate retention of urine, which may render catheterism necessary for a fortnight; and finally undue contraction after the operation, which will entail the use of the bougie.

The other operation, which gives the best results, is done with the clamp and cautery, and consists in drawing down the tumor, embracing its base tightly in the clamp, cutting off enough so that a good-sized stump is left, and cauterizing this thoroughly with the hot iron. It is important to isolate the tumors well, so as to compress them easily and completely; and in cases where the hæmorrhoid joins abruptly the hypertrophied skin, a groove may first be made with the scissors, so that the compression of the neck of the tumor may be more effectual. After the cautery has been very thoroughly applied, at a black heat, the blades of the clamp should be gradually released by the screw. Should any bleeding occur the clamp must be again screwed up, and the cautery applied more thoroughly. This may be necessary several times. The advantages claimed for this operation over that with the ligature are greater safety to life, greater freedom from suffering, more rapid recovery, less danger of pyæmia, of ulceration, and of embolus, and less constitutional disturbance after the operation. The operation is equally applicable to cases of prolapsus.

It will sometimes be found that several of the methods described may be used with advantage on the same class of cases, and the operator must be guided in his choice by all the circumstances of each case. I do not wish to advocate the adoption of any one method to the exclusion of others, and I have found all of them very satisfactory, though much preferring the treatment by injections where a speedy cure is not an object to be considered.

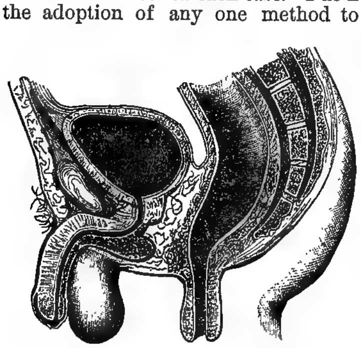


FIG. 210.—First Variety of Prolapse. (Mollière.)

PROLAPSE.—There are four distinct varieties of prolapse, which must be carefully distinguished from each other in their treatment; for the same operation which will cure one variety may lead to a fatal result in another which to the eye closely resembles it. The first consists of a protrusion of the mucous membrane alone, and is sometimes spoken of as partial prolapse, because only a part of the coat of the bowel comes out of the body. It is shown in Fig. 210. It is a mere everting of the mucous membrane of the lowest portion of the rectum, rendered possible by the laxity of the submucous connective-tissue. It is an accompaniment of some old cases of hæmorrhoids, and it is seen in the horse as a natural result of each act of defecation. It is the most common of all the forms. It is most frequently found in children between the years of two and four, and is more common in women than in men. It always comes on gradually, and it may be partial or complete as regards the entire circumference of the anus. It appears as a scarlet or livid mass (depending upon the degree of contraction of the sphincter) covered with the natural secretion of the bowel, directly continuous with the skin on one side and with the mucous membrane on the other; and arranged in folds which radiate from the central aperture toward the circumference. It is at first spontaneously reducible, or at least easily replaced by slight pressure, and remains reduced till the next defecation; but as the amount of prolapsed membrane increases, the difficulty in reduction becomes greater, and finally the mass may be out of the body most of the time from distention and loss of power of the sphincter. In this condition the tumor is liable to become inflamed, œdematous, and irreducible, and the patient is in a very unhappy plight.

The first step in the treatment of this form of prolapse is generally the reduction of the mass. If the patient be in the condition last named all operative interference should be postponed, no attempt at reduction need be made, the patient should be confined to his bed, cold applications used freely, and the tumor smeared with an ointment of equal parts of the extracts of opium and belladonna. After a week of this treatment the tumor will probably be in a condition either to replace or to remove, and the surgeon can judge something of the amount of tissue to be removed, which is not possible when all the parts are œdematous. In ordinary cases the tumor may be reduced by gentle taxis. In children, the patient should be laid on his face, across the knees of the surgeon, and gentle pressure applied with the fingers well oiled. If this does not succeed ether should be given at once and a radical operation performed. In adults, when the taxis has failed and both ether and operation are declined, there is nothing to do but keep the patient on his face in bed with a pillow under the pelvis, apply warm poultices with the ointment mentioned, and trust to time to relieve the condition.

The palliative treatment is directed entirely toward diminishing the frequency and amount of the prolapse, and a cure may sometimes, especially in children, be obtained by these means without operation. They consist briefly in directing the act of defecation to be performed in the recumbent posture, the use of laxatives to prevent straining, the avoidance of any source of irritation which will cause frequent passages, and the use of astringent washes each time the bowel protrudes. The best astringent is cold water or a cold solution of alum (ʒ j. to ℥ viii.). An astringent injection may also be given every night with advantage, and allowed to remain in all night.

A prolapse of this variety in the child or adult may be effectually cured in several ways. In cases attending old hæmorrhoids, whatever operation is done upon the hæmorrhoids, whether it be injection, the ligature, or the clamp, may be extended to the prolapse, and will have an equally good result. There have been some remarkably good results also in cases of old and extensive prolapse from the injections of ergotine into the cellular tissue around the anus. The formula is glycerine and water, of each fifteen parts, and alkaline hydrated extract of ergot two parts. The dose is one gram and twenty centigrams, injected at intervals of several days. The injection may be followed by acute pain, spasm of the sphincter, and spasm of the neck of the bladder, causing retention; and the danger to be avoided is the use of too irritating solutions or solutions in too great quantity, which may cause suppuration or poisonous constitutional effects.

In children a very effectual means of cure is the application of fuming nitric acid to the prolapsed part. The bowel should be thoroughly dried with a towel, and the acid applied with a small stick all over the mucous membrane. The bowel should then be replaced, a pad of lint

Anus and Rectum.

firmly applied by means of a broad strip of adhesive plaster over the nates, sufficient opium should be given to confine the bowels, and the child kept in bed. In a large proportion of cases the cure will be complete with one application, unless a polypus be the exciting cause of the trouble. This treatment is not equally successful in adults, and in old persons deep and dangerous sloughs may result, which may lead to serious hæmorrhage. In them the treatment by linear cauterization is much preferable. It consists in making several deep cauterizations in lines radiating from the centre of the prolapse toward the circumference. Paquelin's cautery with the fine-pointed bent tip is the proper instrument, and after several such cuts have been made it is a good plan to burn through the sphincter on each side, to allow of contraction. This operation must be done with judgment, and the amount of cauterization must correspond with the amount of prolapse. I have never seen a case which could not be cured in this way, for by it the anus may be completely closed by a cicatricial stricture.

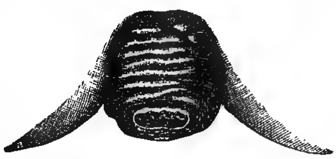


Fig. 211.—Prolapse Composed of all the Coats of the Rectum. (Bushe.)

In old and inveterate cases the fault is generally, however, in not making the cauterizations sufficiently extensive. A portion of the mucous membrane is burned off, but the cuts do not extend into the connective-tissue around the anus as they should.

One other effectual method of dealing with prolapse, whether mild or extensive, is with the clamp and cautery. The operation is essentially the same as that already described for hæmorrhoids.

The second variety of prolapse is that composed of all the coats of the rectum, mucous, submucous, and muscular, and is shown in Fig. 211. The essential point in the consideration of this form of the disease is that the prolapse may contain peritoneum; and it follows, from the anatomy of the parts, that the peritoneal pouch will be larger in front than behind. In the pouch thus formed may be located coils of small intestine, or even the uterus or an ovary. In this form of prolapse there is no groove or sulcus, and its absence is therefore no proof of the absence of peritoneum. Its anatomical characters are well shown in Fig. 212. This variety of the disease generally follows the first, though it may come on suddenly from violent straining. It is distinguished from the first by its size, by greater firmness and thickness to the touch, possibly by resonance on percussion, or by the gurgling of gas in a contained loop of small intestine, by its conical shape, and by the slit-like orifice which is generally drawn to one side by the attachment to the vagina, or by the binding down of the meso-rectum.

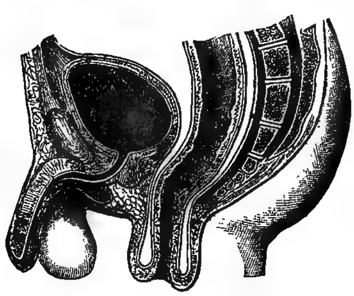


Fig. 212.—Second Variety of Prolapse. (Mollière.)

It is evident that an operation which might cure the first variety might easily end fatally in this one from the presence of peritoneum, and that the possibility of this complication must always be borne in mind. The treatment by linear cauterization is the safest, and the cuts should be made into the substance of the sphincter after the tumor has been reduced, and not into the tumor itself. Excision by the clamp and cautery, or the ablation of the mass by the elastic ligature, may sometimes be done with safety if the surgeon is prepared for an accidental opening of the peritoneum. The palliative treatment is the same as for the other variety, and it is sometimes better not to attempt a radical cure, but to confine one's effort solely to making life comfortable.

The third and fourth varieties will be described together, because they do not differ from each other in their nature, but simply in their extent and location. To both the term invagination is properly applied, because of the ensheathing of one part of the bowel within another, which is shown in Fig. 213. In the third variety the telescoping occurs near the anus, the intruded portion appears at the anus, and the sulcus between the extruded portion and the lower part of the rectum may be felt with the finger. Its depth forms an indication of the length of the contained part. When a portion of the bowel still further removed from the anus has become invaginated into that immediately below, the included portion may or may not descend sufficiently near to the anus to be felt by rectal touch, and the sulcus may not be apparent. This constitutes the fourth variety, and is generally known as intussusception.

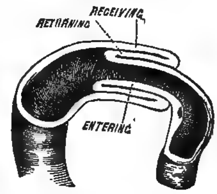


Fig. 213.—Third Form of Prolapse. (Bryant.)

Abscess and Fistula.—Abscesses near the anus may be divided into the superficial, those of the ischio-rectal fossa, and those of the superior pelvi-rectal space. The superficial variety may arise from one of the minute glands around the anus, from suppuration of an external hæmorrhoid, from acute inflammation of an internal hæmorrhoid near the margin of the anus, or from inflammation of the subcutaneous cellular tissue due either to traumatism or to the presence of other rectal disease. In the latter case the abscess cavity, though of considerable extent, is superficial; in the former cases the abscess will probably be distinctly circumscribed. In all of them the knife should be used as soon as suppuration becomes inevitable, that the production of a fistula may be avoided.

An abscess of the ischio-rectal fossa is bounded by the levator ani muscle above, the skin below, the rectum on one side, and the adjacent tuberosity on the other. An abscess of the superior pelvi-rectal space, on the other hand, originates in the lax connective-tissue around the upper portion of the rectum above the levator ani. It may assume vast proportions, blending laterally with the subperitoneal connective-tissue of the iliac fossa, and burrowing in almost any direction in the true pelvis.

The causes of deep rectal abscess are various. Traumatism is perhaps the most frequent, and the injury is generally internal rather than external, being caused by the point of a syringe or foreign body rather than by kicks or falls. A fish-bone may pass entirely through the rectal wall and be found loose in the cavity of the abscess it has caused. Such an abscess may also be due to the injury inflicted by the fœtal head in parturition, and in such a case the diagnosis from puerperal inflammation may be difficult. It may also be secondary to diseases of the urinary organs, and it may result from rupture, ulceration, or perforation of the rectal wall in connection with stricture. Again, it may result from an inflammation of the submucous tissue with the production of pus which first opens into the bowel and forms an internal fistula, and subsequently extends outward and forms a large abscess. Finally, such abscesses may be in their origin entirely disconnected with the rectum and due to disease of some neighboring part or to necrosis of some adjacent bone, or perhaps no adequate cause can be found, so that for lack of knowledge it may become necessary to set them down as idiopathic.

In abscess of the superior pelvi-rectal space the symptoms are often obscure and seldom characteristic. There is more or less vague pain in the pelvis or lumbar region, which is seldom intense and is generally increased by defecation. Fever may be entirely absent, is more apt to be continuous than very high in degree, and chills are only occasionally met with when pus is formed. In addition there is more or less general malaise, and the vesical symptoms (retention and incontinence) are apt to be

Anus and Rectum.

marked. The diagnosis must rest chiefly upon the result of careful digital examination by the rectum and through the abdominal wall. An abscess of the ischio-rectal fossa may at its commencement be marked by the same symptoms, but, later, the skin becomes red and œdematous sometimes over a large part of the buttock, the pain is very severe, and rectal examination impossible. In abscess of the superior pelvi-rectal space, when the disease has extended to the cellular tissue of the ischio-rectal fossa, immense collections of pus may form and burrow in any direction. In men it generally follows the course of the bowel, involves, secondarily, the ischio-rectal fossa, and makes its way through the skin at some distance from the anus, possibly over the trochanter or out on the buttock. In women it is more apt to pursue a contrary course, and may appear on the surface in the groin or near the iliac crest. An abscess of the ischio-rectal fossa generally breaks both upon the cutaneous surface and into the bowel at some distance from the anus, while one in the superior pelvi-rectal space is just as likely to open into the bladder, vagina, or peritoneal cavity, as into the bowel.

The great question in treating an abscess of the ischio-rectal fossa is to avoid the formation of fistula. This can generally be done if the proper course be followed, but the treatment must be prompt and efficient. It consists in etherizing the patient as soon as the diagnosis is made, and without waiting for fluctuation or even for the formation of pus, in making a free incision into the centre of the trouble, thoroughly cleaning out any cavity that may have formed, breaking down all bridles of sloughing tissue, laying open all pockets, washing out the cavity with carbolic acid, and stuffing it with lint. If this be properly done a fistula will be avoided in the majority of cases. If the abscess be left to itself, or even partially opened, a bad form of complete fistula is pretty sure to follow. The treatment of an abscess of the superior pelvi-rectal space is not so simple, the disease being more serious and the prognosis more grave. If possible the abscess cavity should be opened with the knife through the rectum, or it may be evacuated by the aspirator through the abdominal wall. In general, however, it will evacuate itself either into the bowel or bladder before the diagnosis is made with sufficient certainty to justify an operation.

Fistula.—A fistula which is not due to perforation of the rectal wall from within is the result of a previous abscess, and therefore the consideration of one leads directly to the other. Like the abscesses from which they arise such fistulæ may well be divided into superficial and deep; or into those of the anus which are subcutaneous and involve at most only a few fibres of the external sphincter; and those of the rectum and pelvis, which open into the bowel at a higher point or on the surface at a considerable distance, perhaps, from the anus. Both the superficial and deep may be divided into the complete, or those which open both into the bowel and on the surface; the external, which open only on the skin; and the internal, which have an opening only within the bowel (Fig. 214).

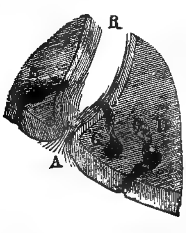


FIG. 214.—Varieties of Fistula. (Gosselin.) A, anus; R, rectum; B, complete fistula; C, blind internal fistula; D, blind external fistula.

In the superficial or subcutaneous fistulæ, the external orifice may be at some distance from the anus or among the radiating folds. It may be so small as to escape the eye in a cursory examination, unless a drop of pus chance to be squeezed out of it by the pressure of the fingers; and when found it may not admit the end of an ordinary probe. A fine probe of pure silver should always be at hand for these examinations. The presence of more than one orifice is rare in superficial fistulæ, and an internal opening will be found just within the sphincter in the great majority of cases if it be properly searched for. Deep or submuscular fistulæ differ greatly in their extent and gravity from those last described. In them the track is large and often double or branching, and the external opening may be far away from the anus. The whole perineum and even the gluteal region will sometimes be found pierced with openings. In these the internal orifice does not in all cases mark the superior limit of the fistulous track. This may run several inches up the bowel under the mucous membrane while the internal orifice is only just within the sphincter (Figs. 215 and 216).

The symptoms caused by this class of fistulæ vary greatly. At first they are those of the abscess in which they originate. After that the one great symptom is the incessant discharge, sometimes slight, at others abundant, sometimes purulent, at others serous, always fetid, sometimes mixed with fæces and gas. Besides the discharge there may be no symptom at all, or there may be more or less uneasiness and pain in defecation.

Blind internal fistulæ, or those which have an opening only into the bowel, have a somewhat special pathology. When caused by an abscess, it is generally one of the deep variety, which has opened into the rectum high up and continues to discharge in this way. The opening may, however, be the result of ulceration, and the track a secondary consequence. A small ulcer which shall perforate the mucous membrane and result in internal fistula may be due to several causes: to rupture of an inflamed internal hæmorrhoid; to the inflammation of one of the lacunæ just above the sphincter, from the lodgement within it of an irritating particle; to the application of strong acids or any other traumatism; or to the peculiar ulceration met with in tubercular patients, but not of necessity itself tubercular. Such a condition is a very painful one. The opening, which may be large enough to show a distinct loss of substance to the touch, catches and retains particles of fæces, causing a burning pain which may last many hours after defecation. As a result of the ulcer, an abscess forms after a time with the usual symptoms. When this is small, and the induration not extensive, a speculum examination may reveal the ulcer, but the track and the abscess may escape—a mistake which will render all treatment directed toward the cure of the ulcer futile. There may be several ulcers, only one of which has a fistula connected with it.

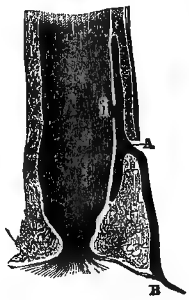


FIG. 215.

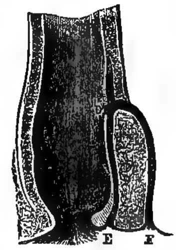


FIG. 216.

Fistulæ with Double Tracks. (Mollière.)

Fig. 215.—AB, deep submuscular track resulting from an ischio-rectal abscess; AI, submucous track running up and down the bowel.

Fig. 216.—DE, subtegumentary and submucous fistula with internal and external opening. DF, deep submuscular track having same internal, but separate external opening.

A fistula may heal spontaneously or after very slight excitement to reparative action, such as the mere passage of a probe in making an examination, but such cases are very rare. Setting them aside, we are brought to the question which will often be asked by the patient, and which the surgeon may not always be able to answer to his own satisfaction,—whether or not it is always best, or even safe, to try and cure a fistula. In certain cases of Bright's disease, cancer, cardiac and hepatic affections, etc., all surgical interference may be plainly contra-indicated; but the question is most apt to arise in connection with pulmonary affections. I believe it to be a safe rule to operate upon phthisical patients as on others, and have many times followed this rule with happy results as to improved general health after the cure of the fistula. There are several rules which should be carefully regarded in this class of cases, however No cautious practitioner would think of operating on an old case of disease which was quiescent and causing little trouble, in a person suffering from very advanced or rapidly advancing lung trouble. Cough, when violent and frequent, is also a decided contra-indication, interfering, as it does very

Anus and Rectum.

certainly, with the healing of the wound. The sphincters should be interfered with as little as possible, for they are apt to be weak at the best; and the general health of the patient must be in no way injured by confinement after operation to secure healing of the wound. I should never urge a patient with advanced phthisis, whose fistula was an old affair and causing him little annoyance, to submit to an operation; but when the trouble is fresh, and, as is most often the case, attended by a good deal of undermining of the skin and profuse discharge, much may be done for his relief, and in the vast majority of cases a cure can be established without any but good results as regards the lungs.

The prevailing idea that to cure a fistula it is necessary to divide the sphincter muscle is often carried to a harmful extreme. Many of them may be cured by much simpler means, and many more of them cannot be cured even by this one. There is, in fact, no rule which applies to all cases. Many sinuses in this part of the body are curable by the well-known means which are used in general surgery—free opening and stimulation. Injections of iodine or nitrate of silver, the application of nitrate of silver fused on a probe, or of strong carbolic acid, the introduction of a fine sea-tangle tent, of a drainage-tube or of a galvano-cautery wire, may any of them be effectual, but are so more often in cases of superficial fistulæ which do not communicate with the bowel than in any other. In complete fistulæ, when not too deep, the best operation is that of incision with the knife. It is shown in Fig. 217, with the addition of the gorget or large wooden director to cut upon, which is often of great advantage. The end of the knife may be passed along the director and firmly fixed in the wood and both withdrawn together. In most cases the director may be passed through the whole length of the fistula into the rectum, where the end may be caught upon the finger and brought down out of the anus before the incision is made. In cases of deep secondary tracks running up and down the bowel under the mucous membrane, as shown in Fig. 215, the operation is more serious. To be sure of a cure they should be divided also, but if hæmorrhage is feared the division may be done with the écraseur or elastic ligature. A small canula may first be passed, through this a wire, and finally the elastic ligature. It will be found, however, that in these cases the sinus is generally under the mucous membrane, and the vessels are in the deeper layers of the bowel. Severe bleeding is seldom met with when the division is done simply with scissors and a director.

FIG. 217.—Operation for Fistula with Gorget. (Bernard and Huette.)

When no internal opening can be found, but the mucous membrane feels undermined, and the probe can be felt by the finger in the rectum, separated only by a thin layer of mucous membrane, it is a good plan to force an internal opening and treat the fistula as though it were complete. When there are two internal openings, both should be included in one incision. When, after the incision, the diseased integument is found to overlap the cut and fall into it, it should be cut away, and in old tracks the healing may be hastened many days by thoroughly scraping out the lardaceous wall with the handle of the scalpel, or scarifying it in several places so that a healthy reparative action may be set up. Where the fistulous tracks exist in great numbers—twenty or thirty in some cases—it may be advisable to do two or three operations at intervals, rather than attempt more than the patient's powers are equal to at one time. In such cases there will generally be found two or three tracks which are primary, the others being merely offshoots from these, and each main track with its branches may be divided in one operation.

Fistulæ of the blind internal variety can only be dealt with rationally by incision. A speculum should first be introduced, and a silver director in the form of a hook passed into the internal orifice, and brought down to the bottom of the track. With this as a guide, the fistula may be opened into the bowel, but the incision should always be continued through the sphincter and anus, so that the wound may be properly dressed and drained; otherwise the operation will only change a small internal opening into a large one.

FISSURE AND ULCERATION.—The many different varieties of non malignant ulcers which are met with at the anus and within the rectum, may best be classified in the following groups: 1, Simple; 2, dysenteric; 3, tubercular; 4, scrofulous; 5, venereal; 6, rodent; 7, those due to stricture; 8, those resulting from sloughing.

Simple ulcers are almost always of traumatic origin, and the most frequent injury to which the rectum is subject is, perhaps, that arising from the passage of hardened fæces. From this cause alone, or combined with their extrusion from the anus, the surface of projecting hæmorrhoidal tumors may become ulcerated for a considerable extent. From this cause also a fissure is often produced within the grasp of the sphincter. Another frequent cause of injury is the presence of foreign bodies, either fish-bones, date-stones, etc., which have been swallowed; or larger substances which have been introduced *per anum*. An infrequent cause of direct violence, and of subsequent ulceration independent of any venereal disease, is sodomy. Cases have been described in which the rectum was dilated, the mucous membrane blackish, swollen, infiltrated, and ulcerated; and the submucous and muscular layers thickened as a result of this vice. The funnel shape of the anus, the lax sphincter, and the absence of the radiating folds are usually quoted as signs of the habit, but they are not at all constant. I have seen the peculiar funnel shape without having any reason to suspect the crime, and I have had patients confess the constant practice of the crime in whom no physical changes could be found. An ulcer of the rectum is often caused by surgical interference, such as operations upon hæmorrhoids or fistula, or unsuitable applications to fissures or prolapse; and, in women, extensive ulceration and subsequent stricture may be caused by bruising the rectum between the head of the fœtus and the sacrum in parturition.

An injury due to some of the causes already mentioned may, in certain persons, and when located at the verge of the anus, assume the characters of an affection which has been elevated into a separate class, and is known as fissure, or irritable ulcer. The irritable ulcer differs in no respect from other simple ulcers in the same locality, except in the fact of its irritability. There is nothing peculiar in the ulcer itself. It may be due to a slight rent in the mucous membrane from hard fæces; to a congenital narrowness of the anal orifice, and a naturally over-powerful sphincter, to the irritation of a leucorrhœal discharge in women; to an herpetic vesicle; or to the venereal sore which it so strongly resembles, the soft chancre. Any sore which is fairly in the grasp of the external sphincter is apt to become an irritable or painful one; and a fissure may be painless at one time and painful at another in the same person; or painless in one person and painful in another. An ulcer associated with contracture, spasm, irritability, pain, and sometimes even with actual hypertrophy of the sphincter, is what is known properly as an irritable one; but a fissure may be present without exciting any of these symptoms. There are two well-known theories regarding the causation of this little sore. One is that the foundation of the trouble is a spasm of the sphincter, and the fissure a secondary lesion due to the passage of fæces through the spasmodically contracted anus. The other, and more correct one, is that the fissure exists first, and that the spasm of the sphincter and resulting pain are reflex, being specially apt to occur in persons of neuralgic tendency, and being in many cases merely the local manifestations of a general nervous state.

These ulcers are generally situated at the posterior commissure, but may be found anywhere on the anal circum-

Anus and Rectum.

ference. They are generally single, but there may be two or three, more especially when they are of venereal origin. They are more common in women than in men, because constipation is more common in the former and because the skin is finer. They are confined to no age and are by no means relatively rare in infants. They are generally oval in shape with the long axis vertical, and involve both skin and mucous membrane, being situated just at the junction of the two. In some cases they have the appearance of a simple erosion, in others of an old ulcer with grayish base and indurated edges which has involved the whole thickness of the mucous membrane and extended fairly down to the muscle beneath. In the majority of cases they are not attended by suppuration or the discharge of pus, but they are apt to bleed a little on slight provocation. They are often attended by small polypi attached near their upper end, or on the opposite side of the bowel, the presence of which may counteract all curative measures directed to the fissure alone.

The ulceration which results from a surgical operation or from a foreign body is easily recognized. Those which result from acute and chronic eczema and from pruritus are generally due to the injury inflicted by the nails of the sufferer, and present no special characteristics. An eruption of herpes around the anus, similar to what is seen on the lips, may result after rupture of the primary vesicles in numerous, small, superficial ulcers of a reddish color, secreting a little pus. These may coalesce at their edges and form a serpiginous sore. They must be carefully distinguished both from mucous patches and soft chancres.

From what has been said of the etiology of these simple ulcers, it is plain that they must present many variations in appearance; yet the diagnosis of each from the other, and of the whole class from those which are to follow, will not generally be found difficult if proper attention be given to the history, the appearance of the lesion, and its course. The disease is generally of a healthy type, and tends to self-limitation and spontaneous cure, rather than to increase. The ulcerative action is generally superficial, and tends to extend on the surface rather than in depth. It is generally surrounded by the signs of reparative action, and with proper care will undergo cicatrization, which, when extensive, will result in stricture.

In dysenteric ulceration the diseased portion of the bowel becomes infiltrated with fibrinous exudation, and, as a result of the pressure which this exercises, is necrosed and sloughs. There results a loss of substance, and if this is superficial, the mucous membrane may regain its former state; but, if deep, the usual cicatrix is produced, which, when of sufficient extent will cause stricture. The ulcers resulting from this process vary much in size, shape, and location. They may be minute circles, but are generally large, and though their favorite site is the rectum or sigmoid flexure, they may be found anywhere in the large intestine. They may extend so as to coalesce and leave only islands of mucous membrane between the extensive patches, and although the process generally involves only the mucous coat, it may extend in depth and result in perforation and its attendant evils. The stricture arising from this form of ulceration is sometimes very extensive.

There are two varieties of ulceration met with in persons of the tubercular diathesis; one due to the actual deposit and softening of tubercle, the other a simple ulceration containing no tubercle, but modified in its course by the patient's general condition of malnutrition. The former may properly be called tubercular ulceration, the latter is better known as the ulceration of the tuberculous. The former is very rare. It may occur in the rectal pouch, or, indeed, anywhere along the course of the alimentary canal, but its favorite site is at the verge of the anus, where it may exist before any general manifestation of tuberculosis. The characters by which such an ulcer may be recognized are its pale-red surface, covered with a small quantity of serum but devoid of healthy granulations and having a varnished appearance; the absence of surrounding inflammation; its tendency to spread in depth rather than on the surface; the absence of any marked pain; the regular outline ending abruptly in healthy skin; its chronicity; and the utter failure of all treatment to arrest its course. The diagnosis may be confirmed by the microscope. A tubercular ulcer starting in the rectum may end in perforation and fistula—fistula with large internal opening—and, as a matter of course, the usual operation in such a case would be followed only by disappointment. Such an ulcer has also been known to cause sudden death from hæmorrhage. The treatment should either be simply palliative, or else should aim at the complete removal of the tubercular deposit, either with cautery or knife.

The other variety of so-called tubercular ulcer is a simple sore in a phthisical patient, modified in its course and character by the general condition. It may result from any of the causes of simple ulceration already mentioned, and any of the simple varieties may assume its characters. It may occur either within the rectum or at the anus, and may vary in size from a spot a quarter of an inch in diameter to a sore covering the whole lower part of the rectum. It neither extends rapidly nor heals easily, and yet it is surrounded by a healthy reparative action, and, unlike the true tubercular deposit, it may be induced to heal and may cause stricture. The disease is essentially a chronic one, and is often known as "chronic ulceration of the rectum." It may easily be confounded with some of the varieties of scrofula to be mentioned.

Under the title of *esthiomène* (lupus exedens of the ano-vulvar region) a number of phagedenic ulcerations, complicated with more or less hypertrophy of the nature of elephantiasis, have probably been described; but, in spite of the confusion of statement, this disease would seem to be a rare manifestation of scrofula, which may precede any others in its development. It commonly starts from the external organs of generation in the female, and invades the anus, rectum, and vagina secondarily. It is almost never seen in men. Its favorite starting point is the perineum, and it may be superficial or perforating, and produce great loss of tissue, turning the rectum and vagina into one cavity. In the late stage other ulcers are apt to appear higher up, causing diarrhœa and sometimes peritonitis; but whether these are simply follicular, or are due to further deposits of lupus has not been determined. The ulcer is irregular in outline, with a granular base of a violet-red color, and there is a slight sanious discharge. The edges are but little elevated, and are not undermined, and there is more or less hypertrophy of the surrounding tissue which, in some cases, is exceedingly well marked. The ulcer may cicatrize in part, the cicatrix being thin and white, at the same time that the ulcerative process is extending in the opposite direction. At a little distance from the ulcer there is often a pathognomonic appearance of slight, reddish, hard nodules of tubercular lupus, separated from the primary sore by healthy skin. With this amount of disease the constitutional disturbance is often not sufficient to confine the patient to the house.

The diagnosis is not generally difficult, though the disease may be confounded with cancer, phagedenic chancroid, and with elephantiasis accompanied by secondary ulceration. It is best distinguished from cancer by the cicatricial bands which it leaves behind in its ineffectual attempts at healing, and from chancroid by the surrounding tubercles which in lupus develop in the thickness of the derma and ulcerate secondarily, while the ulcers which surround a chancroid are ulcerous from the first, being due to secondary inoculation. Van Buren advances the theory that most of these ulcerations are due to the grafting of the syphilitic poison upon the scrofulous diathesis in women of improper lives. The duration of the disease is indefinite, and it seldom leads to fatal results. It is best treated by destructive cauterization and *raclage*.

There are several varieties of ulceration of the rectum and anus of venereal origin. Without attempting to decide upon the specific character of the inflammation which may follow the contact of the gonorrhœal discharge, it is well to call attention to the severity of that inflammation and to the fact that it may cause ulceration and probably subsequent stricture. During the height of the disease the rectum is hot, red, swollen, and granular, and there is an abundant purulent discharge issuing in

clots. The irritation of this may cause erosions and fissures which may reach a considerable size, or a previously existing fissure may become inoculated in this way and may spread in extent.

One of the most frequent of all the superficial ulcerations at the anus is the chancroid. It is much more common in females than in males, constituting one in nine of all cases of chancroids in the former, and one in four hundred and forty-five in the latter. To account for this greater relative frequency it is only necessary to remember the frequency of accidental contact of the male organ in coition, and the facility of auto-inoculation due to the proximity of the vulva. These ulcers are seen either on the skin around the anal orifice or just within the canal, and show a decided tendency not to pass beyond the internal sphincter. They may be single or multiple, and may be situated at any point in the anal circumference, or completely surround it. When several have coalesced the suffering may be severe. The sores have the same characters as in other parts of the body, and the class of women upon whom they are found is an aid to diagnosis. If any suspicion of their real character exists, the test of auto-inoculation may be tried. Sores of this variety tend to spontaneous cure with cleanliness, and, if necessary, with judicious cauterization; and no matter how completely they may have involved the anus or the skin around it, they seldom leave any trace after healing. On the other hand, the cure may be delayed for months, and the sore may assume a chronic type due either to the coexistence of some other disease of the rectum, or to a syphilitic or scrofulous taint in the patient. They may be complicated by a chronic œdema of the surrounding parts, and resemble the lupus exedens already mentioned, or by the gangrenous process known as phagedæna, generally of the chronic variety, advancing in one place while healing in another.

That a chancroid may extend into the rectum, cause great destruction, cicatrize, and leave stricture, seems to be beyond doubt. Van Buren says, "I have certainly seen this in several cases, but only in women;" and Bumstead and Taylor speak in the same way. Bridge's case is generally considered conclusive, though its authority rests much more upon the well-known character of the men who pronounced judgment upon it than upon the history as it stands recorded;[1] for there is at least a strong suspicion of syphilis, and there is no account of the crucial test of auto-inoculation. That chancroid is, however, the most common cause of those grave strictures so often met with in women who have had syphilis, and which are generally known as "syphilitic," is by no means proved. That many of them are not due to this cause is rendered certain by the fact that they are often found in women beyond the suspicion of either chancre or chancroid, and they are often developed late in the course of true syphilis, are not preceded by any ulceration near the anus, where chancroids are usually located, and do have their starting-point in an ulceration well above the internal sphincter.

True chancre at the anus is not very uncommon. Probably many more of them exist than are ever diagnosticated, because they cause so little local trouble. In the female a sore in this location is easily accounted for by artificial inoculation; in the male it means sodomy. They are most liable to be confounded with simple fissures, but have a hard, raised margin and indurated base, are less painful, and devoid of the healthy surface of the former. In a case of suspicion constitutional treatment may be delayed till the appearance of general symptoms. True chancre within the rectum is so rare as to be almost unknown, and the difficulties surrounding its diagnosis are very great. Its mere appearance would scarcely be conclusive, and the absence of any other primary sore would need to be absolutely proved, in women a very difficult thing to do.

One of the secondary manifestations of syphilis is to be looked for at the anus and rectum—the mucous patch, not an infrequent sign in the former locality, and one liable to take on ulceration from local irritation. Generally, however, they are devoid of symptoms, and disappear without treatment, or with simple cleanliness and the use of an astringent wash. That the mucous patch may appear in the rectal pouch also is rendered probable from analogy with the fauces, and such cases have been reported; but they never form cicatrices, and hence need not be counted in the etiology of stricture.

Well-marked cases of tertiary syphilitic ulceration in the rectum, such as are seen in the mouth and throat, are seldom mentioned; and yet that they may exist and cause extensive destruction is not only probable from analogy, but clinically true. It is to this cause that many strictures are due. The ano-rectal syphiloma is not primarily an ulceration, but an infiltration. Like the gummata, however, it leads to ulceration, and the ulceration may cause a "syphilitic" stricture, though the latter result is more apt to be caused by actual blocking up of the canal by the peculiar, doughy, inelastic infiltration.

Rodent ulcer is a rare disease at the anus, but it has been occasionally seen. It is found by preference just at the verge and extending into the canal from this point. It has the same characters as when seen on the face. Its shape is irregular, surface red and dry; it destroys superficially, attacking mucous membrane rather than skin, and undergoes rapid, but only partial, cicatrization under proper local and general treatment. It never entirely heals, and is at first generally mistaken for syphilitic ulceration until the powerlessness of all treatment has been demonstrated. It is one of the most painful of all the affections of the part, and is best treated by complete extirpation, which may prevent a return for some years.

Not only is ulceration the most common cause of stricture, but the latter is generally a cause of the former by its obstructive action, and the changes it causes in the nutrition of the parts. At first there is dilatation of the rectal pouch and hypertrophy of its walls above the disease, due to the effort to overcome the obstruction. In this way the coats may become of double their natural thickness. Next an ulcerative action is set up in the mucous membrane, which begins as a simple congestion, and advances to complete destruction of the tissue over, perhaps, the whole circumference of the bowel, and for several inches above the stricture. As a result, the muscular layer may be entirely denuded, and even perforated, at a considerable distance above the disease. Finally, the gangrene which sometimes follows the continued fevers and is particularly liable to affect the female genitals, and the more severe forms of abscess may, by their extensive sloughing, end in the production of large ulcerated surfaces.

The symptoms of ulceration are quite characteristic. In fissure the chief one is the peculiar pain, which may be constant, but is always increased by defecation. The act itself may not be particularly painful, but after it, sometimes almost immediately, sometimes after a short interval, the characteristic suffering begins, and may last in mild cases an hour or two, or in severe ones nearly all of the twenty-four hours. The pain is described as dull, gnawing, and aching, rather than lancinating, and will often extend into the loins and thighs. Bleeding at stool is also a common symptom, and the extent of the fissure is no indication to the amount of suffering it may cause. The element upon which the pain directly depends is probably the exposure of nerve-filaments. Ulceration within the rectum is also attended by a train of symptoms sufficiently characteristic to render its existence extremely probable when these occur. They are morning diarrhœa of a peculiar kind, the desire for a passage coming on as soon as the patient awakes, and the passages being at first mucus, and finally containing fæces mixed, perhaps, with blood. After a couple of hours these passages cease for the day, and nothing more is felt except occasional pain and a constant uneasiness in the part. As the disease increases, the diarrhœa will return in the evening, the discharge of blood and mucus will increase in quantity, and the pain will become constant and very exhausting. It is scarcely necessary to call attention to the extreme gravity of this condition, or to the certainty with which, if untreated, and sometimes in spite of the best of treatment, it will end either fatally or in stricture. The picture is,

Anus and Rectum.

unfortunately, only too familiar, and a case of ulceration within the rectum is perhaps one which calls for as much skill in treatment and yields as poor results as anything in the range of surgery.

The diagnosis of the presence of ulceration is not difficult with sufficient care. No ulcer within four inches of the anus is beyond the reach of actual touch and vision, and none need therefore escape detection. The rule is simple. If the sore cannot be felt by digital examination ether should be given, the anus dilated, and a thorough speculum examination made of every part. In every case the history must be taken into consideration as well as the appearance of the sore. Of the many varieties mentioned, some are extremely rare. Among these are the true chancre, tubercular deposit, rodent ulcer, and lupus. In most cases, after excluding syphilis, the ulcer will be of the simple variety, modified more or less in each case, or it will be malignant.

The treatment of fissure should in the first place be preventive in those persons in whom the skin is unusually sensitive and liable to crack; and for such there is nothing better than daily ablutions with cold water, and the avoidance of anything which may tend to irritate it, as the use of printed or rough paper after defecation. A fissure may often be cured by applications of weak solutions of nitrate of silver, Goulard's liniment on a pledget of lint, an ointment of oxide of mercury (ʒ ss. to ℥ j.), or the passage of a well-oiled bougie. I seldom find a fissure which cannot be cured by this line of treatment and without the necessity of stretching the sphincter; but with these local measures must be combined the greatest possible amount of rest, and the daily administration of a mild laxative to secure an easy passage. If the pain be severe it is a good plan to have the evacuation late at night just before retiring, and then to use an ointment of belladonna freely. Instead of stretching the sphincter, which involves the previous administration of ether, many cases may be cured by drawing a sharp knife over the base of the ulcer, and cutting sufficiently deep to divide those fibres of the sphincter which are exposed. If a polypus be present it must be removed, else no line of treatment will be of any avail.

The treatment of ulceration within the rectum is a much more difficult matter, but the principle is the same. In both we give the ulcer rest and try to assist nature in her own methods by avoiding any irritation which may interfere with the work of repair. The general treatment consists of absolute rest in bed and fluid diet. Cod-liver oil may also be given when well borne, as a laxative and tonic. The local treatment consists in various applications. Suppositories serve a good purpose and may contain any drug desired, tannin, iodoform, bismuth, opium, belladonna, etc. The practice of introducing local remedies in this form has many advantages over that of applying them by means of a speculum, for the mere introduction of a speculum two or three times a week is apt to do more harm then the remedies will do good. Certain good results may be gained by applications made in the form of enemata, especially when the disease is high up. Three pints of water may be thrown into the sigmoid flexure through a long rectal tube, and parts may be reached in this way which cannot be so by any other method. The drug from which the best results may be expected is nitrate of silver in the strength of from twenty to forty grains to three pints of water. The application of pure nitric or carbolic acid to an ulcer within the rectum is often followed by immediate reparative action. It is especially indicated in syphilitic disease which has failed to respond to constitutional treatment. In cases of more extensive disease above the sphincter, where the latter by its action causes constant pain, I am in the habit of freely dividing that muscle in the median line, posteriorly, with the cautery knife. In this way relief is given to suffering, more perfect rest is obtained for the parts than is otherwise possible, and a way is opened up for such further local treatment as may be necessary. The operation is preferable to that of stretching the muscle, because its effect is more permanent and because it permits of free drainage. It is, in fact, an excellent substitute for colotomy in a certain class of severe cases of otherwise incurable disease.

Stricture.—Stricture of the rectum may be congenital or acquired. The congenital will be referred to under the head of Malformations. Acquired strictures may be divided into, 1, those due to pressure from outside the bowel; 2, spasmodic; 3, non-venereal; 4, venereal; 5, cancerous.

A tumor of any kind in the pelvis will not infrequently so press upon the rectum as to obstruct its calibre. An abscess in the ischio-rectal fossa may be accompanied by an amount of inflammatory deposit around the rectum sufficient to cause a considerable bulging inward of the wall; and a pelvic inflammation in women may be accompanied by an amount of exudation which, in the form of bands across the bowel, shall partially close it, and, at the same time, lead to compensatory muscular hypertrophy of the rectal wall. Medical literature is full of such cases, and here it is only necessary to refer to them.

Much has been written in the past upon the question of spasmodic stricture, but the condition is looked upon by the best authorities with great doubt. Spasmodic contraction or stricture of the external sphincter muscle is not an unusual condition, but spasmodic contraction of the canal above that point has always been a matter of belief and of assertion rather than of demonstration. It is upon the difficulty encountered in passing a rectal bougie that nearly all of the supposed cases rest. When a bougie cannot be passed, a stricture is inferred. When, after numerous trials, an entrance is finally effected by lucky manipulation, the spasm has been overcome. To this may be reduced nearly all the reported cases of this affection, which from time to time have appeared in the writings of those who have devoted attention to the subject. It is perhaps too much to say that spasmodic stricture never exists; but a well-marked contraction within reach of the finger, which can be plainly detected by an ordinary digital examination, and which disappears under anæsthesia, is yet to be reported, although more or less spasm may be an accompaniment of other severe rectal disease.

Non-venereal strictures may be divided into the dysenteric, the inflammatory, and the traumatic. Dysenteric ulceration has already been spoken of, and strictures due to this cause are often very extensive, and not infrequently multiple. Proctitis, whether acute or chronic, when sufficiently severe and attended by sufficient changes in the coats of the bowel, may result in stricture; and a simple traumatism may lead to the same result, either by causing ulceration and cicatrization, or by exciting a chronic inflammation in the submucous connective-tissue. Among these traumatisms may be enumerated operations upon hæmorrhoids, applications of strong acids, the performance of some surgical operations, foreign bodies, kicks and falls, and the injury produced by the head of the fœtus at birth.

There is another form of stricture which may be considered as on the dividing line between the congenital and the inflammatory, and which consists in an enlargement and thickening of the folds of mucous membrane which are normally present in every one. Cases have been reported in which these folds became sufficiently hypertrophied to act as a stricture and cause obstruction and accumulation of fæces above. The idea that these folds are the starting-point of many strictures is quite a general one, and probably has its foundation in the fact that as they are the most subject to injuries, so they may be the most frequent starting-point of those contractions which are due to injuries, especially those from foreign bodies introduced per anum, and from hardened fæces, intestinal concretions, etc.

The venereal strictures may be divided into two varieties, the cicatricial and neoplastic. The venereal ulcerations which, by subsequent cicatrization, are capable of producing stricture have already been referred to. They are the chancroid and the later syphilitic ulcers. The true chancre and the mucous patch may be left out of consideration, for the reason that their influence in causing stricture is still rather a matter of surmise than of

Anus and Rectum.

proof; and the same may be said of gonorrhœa of the rectum. There is another class of venereal strictures which are not primarily ulcerative, and, therefore, not cicatricial; these may be denominated neoplastic. In this class are to be placed the gummata; the ano-rectal syphiloma, which differs from gummy deposit rather clinically than microscopically; and a third late manifestation of syphilis, which is an inflammation of the rectal wall. This inflammatory change may involve a large portion of the rectum. It begins in the muscular fibre, the interstitial tissue of which becomes filled with round cells, which ultimately form a connective-tissue, and this connective-tissue, by its hardening and consolidation, finally causes the complete destruction of the muscular element. It is not to be confounded with ano-rectal syphiloma, in which there is an actual deposit of large masses of new material in the rectal wall, masses which it may be very difficult to distinguish from cancer. In these various ways venereal disease, and especially syphilis, may result in stricture, and this accounts for the fact that in about fifty per cent. of all cases there is a syphilitic history.

In studying the pathological anatomy of stricture there are several points to be observed, for changes will be found not only at the stricture itself, but above and below it, and in the surrounding parts. The mucous membrane at the constriction will be found destroyed, and all the connective-tissue, whether submucous, subperitoneal, or intermuscular, will be found increased in quantity, thus increasing the thickness of the rectal wall. Above the constriction a process occurs which will be found to be almost constant. It begins as a dilatation of the bowel and an hypertrophy of the muscular layer, with, at first, a thickening of the mucous membrane. Later the mucous membrane, due probably to the irritation of retained fæces, will show all the stages of ulceration, from simple congestion in some points to a complete destruction in others, and an exposure of the muscular fibre beneath. This ulcerative process may extend several inches up the bowel, and the bowel above the stricture may become as thin as paper in spots, and may tear almost as easily. At such points perforation is apt to occur. The bowel is also generally distended with gas and fæces, the latter being more often fluid than solid, though fæcal tumors will sometimes be met. The dilatation may reach an enormous size, and ultimately result in a pouch which will fill a great part of the abdomen, and dip down in a *cul-de-sac* below the constriction. An ulceration and perforation of such a pouch may result in the establishment of a fistulous outlet for the fæces, and such an outlet may be into the rectum below the stricture, the bladder, the genital tract in females, or into the ischio-rectal fossa, with the necessary result of abscess. The cellular tissue around the lower part of the rectum may also become hard and lardaceous as a result of chronic inflammation, and this process may extend a considerable distance from the stricture along the sacrum up to the promontory and into the subperitoneal tissue of the iliac fossæ. Abscess is always liable to accompany stricture, for an unknown reason, perhaps from the lowered vitality of the part, and this accounts for the relative frequency of fistulæ in this disease. These may be both numerous and extensive, and may make communications between the rectum and any of the neighboring organs. There is also a low form of peritonitis which frequently accompanies stricture, marked by tympanites, vomiting, and pain, and attended by thickening of the peritoneum and adhesions. Below the stricture the rectum will sometimes be found unchanged from its normal condition, but it will generally be ulcerated as it is above, or else there will be hæmorrhoids, excoriations, vegetations, and cutaneous tags of greater or less size. These growths are the result of the irritation of the discharge from the disease above.

Most strictures are located in the lower part of the rectum, and hence their presence is easily detected in the majority of cases. They are far more frequent in females than in males, because many of the causes which produce them operate chiefly in females. Age has little influence upon their frequency after the period of adult life. A stricture may or may not involve the whole circumference of the bowel; and the contraction may be so slight as not to be apparent till the bowel is stretched by the speculum, when a falciform band may spring out from one side. In more extensive disease there is still usually a passage for the fæces, but it may be very small. The most extensive disease will be found to be due generally either to syphilitic deposit, syphilitic sclerosis, or dysentery, and in such cases the stricture tissue may cover a space of several inches, beginning near the anus and reaching nearly the entire length of the rectum.

When stricture is the result of ulceration, the symptoms of the latter will generally mask those of the former, and the patient will complain of pain and discharge, with failure of the general health, and gastric and intestinal disturbance. The one sign of a stricture is the obstruction it causes, and this may show itself in several ways, generally at first by alternate attacks of constipation and diarrhœa. The constipation is mechanical, and is due to the accumulation of fæces above the barrier. The diarrhœa is secondary to the accumulation, which in time begins to act as a foreign body, setting up a catarrhal inflammation, as a result of which sufficient fluid is poured into the bowel to soften the hardened mass, and large quantities are discharged, only to be followed by fresh accumulations. It has often been asserted that a lessening of the rectal calibre must, in the nature of things, cause a change in the shape of the fæces, and flattened, tape-like stools are given as a diagnostic sign of stricture; but this is not quite true. The tape-like stool is a sign of value when present, and should always lead to careful exploration, but it may not be present in the worst case of stricture, and it may be present without stricture; in the latter case being due to spasmodic action of the sphincter at the moment of defecation. A stricture, even of large calibre, may, as a result of straining, cause a passage of very small size and tape-like appearance, but to do so it must be forced down to the anus in defecation, so as to actually take the place of the sphincter and impress a final mould upon the matter passed. It is well known that with a very tight stricture high up, the fæces may be re-formed in the rectum below, and be passed normal in size. At the bedside but little weight is to be attached to the statements of patients regarding this matter.

After a stricture has existed for some time signs of obstruction may be manifest by abdominal inspection and palpation. The transverse and descending colon can be felt partially distended with fæces, and will be dull on percussion and tender to the touch, while movable tumors, pitting on firm pressure, may be made out. After an attack of diarrhœa or a brisk purgation, these accumulations may disappear, only to form again after a time. Generally complete obstruction does not occur without ample warning in this way. It is preceded by eructations of fetid gas, the abdomen swells and becomes very tender on pressure, the coils of intestine are visible through the abdominal wall, and their violent peristalsis gives proof of the effort nature is making to overcome the obstruction. After a few days the patient is exhausted, and unless aid is given dies. Complete obstruction has been seen to occur very suddenly, forming almost the first indication of serious disease; and this is more apt to be the case where the stricture is high up in the rectum or at the junction with the sigmoid flexure. It comes on with the usual signs of acute intestinal strangulation—pain, swelling of the abdomen, bloody passages, etc.—and it may be caused by some indigestible substance which has been swallowed and refuses to pass the stricture, or merely by hardened fæces or prolapse of the bowel above into the constriction.

The first means of diagnosis in stricture is the examination with the finger, and, as the great majority of strictures are confined to the lower part of the rectum, this is in itself generally sufficient. It is the best, safest, and least painful of all the means of diagnosis when properly executed, and yet it may be the immediate cause of death when roughly practised. There is an inborn tendency on

the part of many, when the index-finger comes in contact with a tight stricture, to bore through the narrow passage and feel what is on the other side, a tendency to be overcome. If the examiner be deliberately determined to practise divulsion, this is one way to do it, but divulsion is not necessary for diagnosis, and is, moreover, a very grave surgical procedure. The finger should, therefore, be passed gently up to the stricture, and unless the calibre admits of it without straining, it should not be passed farther. The condition of the parts below may also be appreciated, the amount of induration estimated, and a general idea formed of the nature and extent of the disease. In women the vaginal touch will generally be found of the greatest value and should never be omitted. As a rule all can be learned in this way that can be learned in any other, where the disease is within reach of the finger, and nothing is to be gained by a painful speculum examination or the use of a bougie—means of diagnosis, which, however valuable where the stricture cannot be felt by the finger, are of little use for the lower four inches of the rectum.

When a stricture is situated high up in the rectum or in the sigmoid flexure, the confidence in diagnosis which comes from actual contact of the finger with the disease is entirely lost, and there is, perhaps, nothing in the whole range of surgical diagnosis which requires more skill than the detection of stricture in this part, and nothing attended with more uncertainty. The symptoms are not as marked, for the nerve-supply is not the same, nor is the sphincter involved. For this reason the patient is apt to make the diagnosis of chronic constipation and dyspepsia for himself rather than that of hæmorrhoids. Pain in the abdomen, not particularly localized, pain in the loins and down the legs, obstinate constipation, and occasional diarrhœa, are the things usually complained of, and in these there is nothing to base a positive diagnosis upon. The fæces may never present any peculiarity of shape. They are apt to be lumpy or unformed rather than misformed: but they may be streaked with blood and slime, which is perhaps the most valuable of all the symptoms of the disease, and one which always positively calls for the most careful physical examination.

A stricture in this locality must always be examined for with the greatest gentleness, and the result will often be negative. The attempt to decide the question by the use of bougies is altogether unsatisfactory, and by no means free from danger. It is unsatisfactory because an obstruction will generally be encountered in trying to pass an instrument of any size through this part of the bowel, and the passage of a small one, which is much easier, proves nothing. It is dangerous because with the ordinary rubber rectal bougies a diseased bowel may easily be ruptured with what seems to the operator to be no more force than is justified in attempting to overcome the natural obstructions in this part of the canal. The bulbous-pointed bougie on the flexible stem appears *a priori* to be the most suitable for exploration, but it has two objectionable features. It is not at all an easy instrument to pass, and if passed through a stricture too much force is required for the withdrawal after the abrupt shoulder is in contact with the stricture. A bougie intended for this purpose should be of soft rubber, very flexible, of good size, hollow, and with an opening at the lower end which will fit tightly over the small tip of an ordinary Davidson's syringe, which should be fitted to it before the attempt to pass it is begun. Then, with a basin of warm water close at hand, the bougie may be well oiled and introduced, and at the first obstruction the bowel should be filled with water until it is moderately distended. In this way the folds of mucous membrane are effaced by distention, and one great obstacle is eliminated. The next is the promontory of the sacrum, which is more easily passed by a soft than a stiff instrument. Without these precautions, and sometimes with them, the inexperienced examiner will find a stricture in the rectum of nineteen persons out of twenty, no matter how healthy they may be; and for this reason it is seldom safe to rest the diagnosis of stricture on the fact that a bougie cannot be made to pass. Moreover, a good-sized bougie will often pass a stricture which is small enough to produce marked symptoms.

In certain cases information may be gained by the use of a long, cylindrical speculum, while the patient bends over a chair and strains to bring the parts into view; and it is worth remembering that a full inch may be gained in a digital examination by having the patient stand erect and strain down upon the finger. Fortunately, however, we are not limited to any of these means for a diagnosis. Most strictures in this part of the bowel are cancerous, their presence can be pretty accurately surmised from the general symptoms, and after a time they can be felt through the abdominal wall by careful palpation. If the diagnosis cannot be made in this way, and the symptoms justify it, there is but one means left—the passage of the hand into the rectal pouch. I know of no other way than this by which a stricture of the sigmoid flexure which cannot be felt by external manipulation can be certainly recognized.

The treatment of stricture of the rectum is both constitutional and local. The first question to be answered is as to the advisability of anti-syphilitic treatment, and in recent cases where there is the slightest ground for suspecting syphilis this should never be omitted. It is well to exercise caution in the matter, however, and the cases in which the patient should be submitted to this form of treatment must be carefully selected. The practitioner who considers the great majority of strictures as syphilitic, and indiscriminately uses mercury and iodide of potash, will be mistaken about as often as he who looks upon most of his cases as cancerous, and, therefore, incurable. The general condition of a patient with stricture is never up to the normal, and an unnecessary course of medication may do great harm instead of good. Cicatricial tissue, even though the result of syphilis, is beyond the reach of specific treatment; but where the case is seen early enough, much improvement can be gained by a thorough course of mixed treatment, and a gummatous deposit, or a syphilitic sclerosis may be checked. Mercury and iodide of potash should both be given, neither being trusted alone. The former, as an ointment or as the oleate, may also be administered by the rectum, and the full constitutional effects of the drug may be obtained in a very short time by this means; it is, however, an irritating application, and in cases of much ulceration and sensitiveness it may not be well borne. In cases of ano-rectal syphiloma, also, good effects have been observed from a thorough course of mercury with potash.

There are various other means by which the comfort of these patients may be increased without recourse to operative treatment. The most effectual of them will be found to be a careful regulation of the diet, and rest in the horizontal attitude. The diet should be mostly fluid, and preferably milk. If milk is complained of, soups may be substituted; and where milk is constantly taken in large quantities it may be necessary to add a mild laxative to produce daily easy evacuations. A certain amount of farinaceous food may be allowed, but the best diet is the one that leaves the least residue. The bowels should move daily without straining. Should any medication be necessary to effect this, the mineral waters, Rochelle or Glauber's salts, or the compound licorice powder will be amply sufficient. Purgatives are always contraindicated in stricture of any variety, because they cause straining and tenesmus, increase the tendency to congestion and its consequences, and because, where obstruction actually exists or is threatened, they may do great harm by exciting violent peristalsis in an already weakened and ulcerated bowel. The opposite condition of diarrhœa is more difficult to meet, and often cannot be controlled by direct medical treatment, depending as it does upon the ulceration associated with the stricture. It is best treated by diet, rest, bismuth and morphine, and an occasional astringent injection. The general strength must be carefully supported, and in most cases where it is well borne cod-liver oil will serve a good purpose. When obstruction actually exists much may be done in the way of general treatment before resorting to operation. Food should be almost absolutely suspended; opium should be

Anus and Rectum.

given in large doses to allay peristalsis; and large poultices covering the abdomen will give great relief to suffering. Great benefit has been seen from the administration of belladonna in doses of one or two grains of the extract at short intervals. No purgatives should be administered, and tapping the bowels with the aspirator is a dangerous proceeding.

The various means of local treatment may be included under the three general heads of dilatation, division, and colotomy. Dilatation may be either gradual or sudden, partial or complete. The use of bougies for gradual dilatation is an example of good practice originating in false ideas. It was first adopted with the idea of destroying the stricture by the action of medicinal substances applied in this way. Experience, however, soon proved that simple bougies were no less efficient than medicated ones, and the improvement was then supposed to be due merely to the mechanical stretching of the part, and the instruments were introduced as often, and allowed to remain in as long as possible—an idea still unfortunately very popular. The bougie is intended by its presence merely to excite absorption of organizable matter, and if the pressure be too great, too long continued, or too frequently applied, it will cause more than sufficient irritation for this purpose, and will induce again the very condition it is intended to overcome. The rules which should guide the surgeon in this plan of treatment are now well understood and generally admitted. The dilatation should be intermittent and not constant. Attempts at constant dilatation by means of a bougie of any sort which shall remain permanently in place, generally result either in failure or actual disaster. They are never well borne, and when persisted in, the rectum becomes irritable, the suffering is greatly increased, and the patient is exposed to the risk of peritonitis and cellulitis. The dilatation should never be forced. A bougie should be chosen which will readily pass the stricture without stretching, and if there be any doubt in the operator's mind about the proper size of the instrument to be used, one should be selected which is too small rather than too large. The instrument should never be passed oftener than every alternate day, and twice a week may be better still. Little is gained by allowing it to remain for any length of time within the grasp of the stricture. In cases associated with much ulceration, dilatation by bougies is very apt to make matters worse instead of better; and, if used at all, it should be with the greatest gentleness. As to the kind of bougie to be used, the softer and more flexible the better. When the stricture is within reach of the finger I invariably use my finger instead of a bougie. Practised in this way much good may be done by this treatment. The patient may be greatly relieved and made very comfortable. It must, however, always be continued indefinitely, for it does not cure the disease. A rectum which has once been the seat of an old stricture can never be made as it was before the disease by this or any other treatment. But though the measure may not be curative, it is perhaps as valuable a palliative as is at the command of the surgeon, and by it in suitable cases a patient may be kept in comfort for life. It is applicable to all strictures, malignant or benign, which are within reach from the anus; but when the disease is high up it is not entirely free from danger.

The dilatation instead of being gradual may be sudden and forcible. This is known as divulsion, and for it various instruments have been invented, all of them with the idea of tearing open the constriction by the use of a considerable amount of force. The operation may be commenced by nicking the stricture in one or more places with a knife before using any force, and this combined cutting and stretching operation has sometimes been attended by excellent results, when followed by gentle dilatation at intervals. In cases of very slight stricture with actual obstruction, almost immediate relief has been obtained, and much time has been saved; but unless the patient be in immediate danger the more gradual plan of treatment is the safer. The dangers attending divulsion are hæmorrhage, laceration and rupture of the bowel, peritonitis, and abscess; nevertheless a few very happy results have been achieved by it, and it is particularly applicable to strictures of slight extent with a sharp, well-defined edge.

The unsatisfactory results of dilatation, and the natural objection on the part of both patient and surgeon to the operation of colotomy, have given rise to another method of treatment which within a few years has assumed, deservedly, considerable prominence. This is the operation of proctotomy, or complete division of the stricture by a single deep incision. Either the knife shown in Fig. 218 or Paquelin's cautery may be used, but the latter is preferable, because no blood is lost and the wound requires no after-dressing. The operation of internal proctotomy consists in dividing the whole of the stricture tissue in the median line anteriorly or posteriorly; the incision extending completely through the disease, and generally down to the sacrum. It is called internal because the incision is within the rectum and does not involve the sphincter, and it is usually performed with the knife. It is simply the old operation of nicking the edge of the stricture carried to a greater extent, and is subject to the same dangers in a greater degree. Although at first sight a less serious operation than the external one next to be described, it is subject to more complications, because the sphincter soon regains its contractility after stretching, and prevents the free discharge from the wound which is so desirable. In a few days the rectal pouch is constantly bathed in a purulent and fetid discharge which has no chance of escape except by the voluntary effort of the patient—an effort which he or she is in no mood to make—and the liability to pelvic inflammation and systemic infection is in this way greatly increased. The operation has, however, been attended by excellent results. The danger of hæmorrhage is not very great when the incision is in the median line, as it should be. When the cut is anterior as well as posterior the anatomical relations must be carefully borne in mind, but the single posterior incision is much preferable.

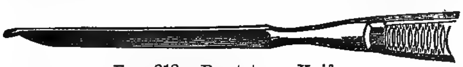


FIG. 218.—Proctotomy Knife.

External proctotomy involves not only the division of the stricture, but of all the tissue below, including the anus. It may be performed with the knife, cautery, or écraseur. The best position for the patient is the lithotomy position, and if the knife is used the whole incision may be made at one stroke, the blunt point being passed through the stricture and a long deep cut being made, dividing, first, all of the diseased tissue, and gradually deepening as it approaches the anus till nearly everything between the anus and the tip of the coccyx is included. The wound should be triangular, with the base at the perineum and the apex in the rectum above the disease, and it should be so made as to allow of free escape of all discharge without the formation of any pockets. If the knife is used there will be a free gush of blood which will necessitate packing the rectum with lint, and for this reason the operation with the cautery or écraseur is preferable. The operation with the cautery consists in making the same deep incision, only in commencing at the perineum and gradually extending it upward by successive strokes until the stricture itself is cut through. The operation with the écraseur consists in passing the left index-finger through the stricture as a guide, and then plunging a trocar from a point in the median line just in front of the tip of the coccyx into the rectum till it reaches the tip of the finger. After drawing out the trocar a fine bougie is passed through the canula into the rectum and brought out at the anus. Removing the canula the bougie is replaced by the chain of the écraseur and the operation is completed. The subsequent treatment of the incision consists wholly in cleanliness. When the rectum has been filled with lint some of it should be removed as soon as it is safe to do so, to give the patient ease, and the remainder may be left till it has become loose by the discharge. When the cautery has

been used the parts need not be disturbed till the third day, when injections of warm water and carbolic acid or chloral should be begun, and continued night and morning for some time. No particular attention need be given to regulating the passages after the third day. The first one will often be the most comfortable the patient has had for years.

It may be asked why so much tissue should be divided below the actual disease. In the first place, this incision provides for free drainage and discharge in the most effectual of all ways, by furnishing a dependent, gutter-shaped opening which cannot become closed. This is better than any amount of drainage-tubes or antiseptic dressings. In the second place, the sphincter muscle is often the chief cause of pain in this disease, and its division a source of the greatest relief. It should be remembered that this operation is put forward as a good and sufficient substitute for colotomy, applicable to nearly all of the same class of cases to which the latter is applicable, and if it accomplishes the same results infinitely preferable in every way. The results sought for by colotomy are the formation of a new outlet and the relief of pain; in proctotomy, the re-establishment of the old outlet and the relief of pain. The free division of the sphincter is an important element in effecting the latter result. This operation is perhaps the greatest advance which has been made in this branch of surgery for many years. Its results are so uniformly satisfactory that there seems to me to be no more indication for the establishment of an artificial anus in the loin in most cases of stricture of the rectum, malignant or benign, than for the formation of a permanent vesical fistula in cases of stricture of the urethra. There are certain cases beyond its reach—cases of stricture too high up for its safe performance, and cases of such extensive ulceration and fistulous burrowing that the powers of the patient are unequal to healing the wounds which an attempt to restore the natural passage would render necessary. In this comparatively small number of cases colotomy may be the only resource, and with this exception the operation should be confined where it properly belongs—to cases of congenital malformation where the natural outlet cannot be established. I have never known this operation to fail of accomplishing the results pointed out, but too much must not be expected of it. After it, as after colotomy, there is still a diseased rectum, which must be treated by every possible means, and the incision is only the first step in the cure. The stricture is easier to overcome than the ulceration which accompanies it. In some cases this too may be cured by patient effort, but not in all; the chances, however, in favor of it are infinitely better after the operation than before.

The last resort of the surgeon in the treatment of ulceration and stricture of the rectum is colotomy. In the former it may be curative; in the latter it is only palliative. It has already been pointed out how the good results of this operation may be attained by means infinitely preferable in a great many cases. It still remains, however, the only resource in cases of stricture too high up to be safely operated upon from the anus, in certain cases of recto-vesical fistula and of imperforate rectum, and in some cases of extensive ulceration and fistulæ without stricture, where it is desirable to give the rectum as much rest from the contact of the fæces as is possible. It has yet to be proved that colotomy delays the progress of cancer of the rectum, though it prolongs life by preventing obstruction and relieving pain. Proctotomy does the same, and in almost direct proportion as the operations of proctotomy and of partial and complete excision of strictures have become popularized and their advantages have become manifest, the operation of colotomy has been limited and the natural objections to it on the part of both surgeon and patient have been allowed more weight.

CANCER.—Cancer of the rectum, like the disease elsewhere in the body, generally occurs in middle life or old age, but it has been seen in a child of six years. It is about equally frequent in males and females. Its favorite site is the rectal pouch, three or four inches from the anus; next to this it is most frequently seen just above the internal sphincter, and after this the junction of the rectum and sigmoid flexure will be found to be its favorite starting-point. Here it seems to run a more rapid course than elsewhere, or at all events accomplishes its fatal work more quickly from the increased liability to obstruction which the anatomical condition favors.

A cancer of the rectum may, and often does, begin so insidiously that its existence is not suspected for months by either patient or physician. Slight wandering pains, occasional diarrhœa, and perhaps an occasional mixture of blood with the passages, often lead to a diagnosis of ulceration, and the usual treatment of this condition is followed without effect. After a time the pain becomes a more marked symptom; the diarrhœa and discharges of mucus and blood become more frequent; there is emaciation and cachexia; a rectal examination is finally made, and if the disease is within reach of the finger the diagnosis is at once apparent. If the disease be higher up, the diagnosis may be made by exclusion. The morning diarrhœa—a fluid passage immediately on rising, and another which the patient will describe as having an appearance of coffee-grounds or molasses mixed with fæces, soon after breakfast—is exactly the same in cancer as in non-malignant ulceration, and should always excite suspicion. The presence of steady, severe pain, either localized at one point in the pelvis or shooting from one point into the loins, the testicles, or the thighs, is a symptom of great importance. It is often the only one of which the patient will complain, its severity causing the diarrhœa to sink into insignificance. I have more than once made the diagnosis from these two symptoms alone, in cancer too high up to be felt or seen, and it is not apt to be wrong; for the diarrhœa is diagnostic of ulceration, and the pain (dull, steady, exhausting, never intermitting) generally means the presence of a new growth. The hæmorrhage is seldom profuse enough to be dangerous, but it is pretty constant, and is an element in the wasting which the disease causes. The symptoms directly referable to contraction are often slight, and differ in no way from those caused by the simple fibrous stricture already described. It is often astonishing to find an advanced case of scirrhus in which the calibre of the bowel is so nearly occluded as scarcely to admit the end of the index-finger, and yet in which the patient has never had any symptoms of obstruction. When the cancerous mass once begins to break down and ulcerate its extension is limited by no tissues of the body. The bladder may be opened and a permanent fistula result, causing more pain than the cancer itself. The prostate and seminal vesicles in the male, and the recto-vaginal septum in the female may each be destroyed, and any part near the disease may be involved. The lymphatics from the anus to the groin, and those from the rectum to the hollow of the sacrum, may each become involved, and should both be examined.

In a general way it is undoubtedly true that benign growths in the rectum increase slowly, tend to grow away from the wall of the bowel and to form pedicles for themselves, to remain circumscribed and movable, and not to infiltrate the surrounding parts; while cancerous tumors have just the opposite characteristics. In this way the diagnosis sometimes is perfectly plain to the touch in the rectum. The stony hardness of scirrhus which has infiltrated the surrounding parts, or is still circumscribed and nodular; the softer, ulcerated, bleeding, warty, flat epithelioma which has spread rather in surface than in depth, but is located on a hard base, and has hard and raised edges; and the soft, cauliflower surface of the colloid tumor which breaks down under the finger, are all diagnostic to the touch. The history, the age of the disease, the cachexia, the glandular involvement, and the secondary deposits in the viscera, all help in the diagnosis. When the disease is too high up to be felt by the rectum, it can generally be made out by careful abdominal palpation.

The treatment of malignant disease of the rectum is designed to be either curative or palliative. In a small number of selected cases a cure is perhaps possible; at all events the disease may be removed and its return delayed for so many years as to give rise to the hope of permanent

cure. This, of course, can only be effected by excision, and this operation may be performed in several ways. When the growth is distinctly circumscribed and is above the sphincters, the anus may be dilated and the mass seized, drawn down, and surrounded by the wire écraseur. The edges of the wound may be brought together or left open, but drainage should always be provided for, either by dividing the anus posteriorly, or by inserting a drainage-tube through a track provided for it, which shall communicate with the wound above, and perforate the healthy skin at a point outside the anus near the tip of the coccyx. When dilatation does not suffice to allow of easy access to the tumor, the rectum and anus may be freely divided posteriorly as the first step in the operation. This incision, when made, should be left open for drainage and not closed with antiseptic precautions.

In cases of more extensive disease involving all, or nearly all, of the circumference of the bowel, and rendering the removal of the entire anus and lower part of the rectum necessary, the operation is more difficult, and special reference must be paid to the hæmorrhage, which may be so serious as to prove fatal. Cripps performs the operation boldly and rapidly. The median posterior division is made at one stroke with a strong curved bistoury introduced within the rectum and brought out at the tip of the coccyx. The buttock is then drawn away from the anus to put the parts on the stretch, and a lateral cut is made commencing at the posterior one and extending around the rectum to the median line in front. The site of this incision, whether in the rectum or outside of the anus, depends upon the location of the disease, and whether or not the anus is implicated. The cut should be made boldly, and deep enough to reach well into the fat of the ischio-rectal fossa. The forefinger in this incision will readily separate the bowel from the surrounding tissue, except at the attachment of the levator ani, which should be divided with knife or scissors. A piece of sponge is pressed into this cut to restrain the bleeding, while the other half of the rectum is treated in the same way. The greatest difficulty will be encountered at the anterior portion, where a careful dissection, aided by a sound in the urethra, may be necessary. When the dissection has been carried to a point above the disease, the bowel is drawn down and held while the wire écraseur is passed over it and the section is made at the required level. After this the hæmorrhage may be free, but is seldom serious. The vessels divided in the first part of the operation all come from the wall of the bowel, and if ligatured when first cut, are divided again by the écraseur. If an effort be made to carefully dissect out the bowel, beginning at the anus and following it closely from below upward, the same vessel may be cut and tied almost as many times as there are strokes with the scalpel. When the disease involves only one side of the bowel, the operation is modified accordingly. The dorsal cut is the same, and the lateral incision is made on the affected side. At the further end of this lateral incision, away from the dorsal one, a needle carrying a cord at its point is passed around the disease and into the rectum above it. The loop of cord is brought out at the anus, attached to the chain of the écraseur, and withdrawn as it entered. The chain is then made to cut its way out, and a rectangular piece of the rectum is thus included between two incisions, one posterior and one lateral. In this rectangle is the disease, and it is dissected upward from below, and separated above by again using the écraseur. Instead of using the écraseur, all of these incisions, except the final one, may be made with the cautery knife, and nearly all bleeding may be avoided.

A wound into the vagina, though always to be avoided if possible, may often be necessary in order to fully remove the disease. When the opening thus made is not too extensive, it may be closed immediately after the operation. A wound of the male urethra, when slight, is to be treated as though the patient had submitted to an external urethrotomy, by the frequent passage of the sound to prevent contraction. When a large piece has been taken from the urethra a permanent recto-urethral fistula is the necessary result, and the danger of fatal inflammation is increased by the presence of urine in the rectal wound. When the peritoneum has been opened it should be closed with catgut ligatures, though many cases have done well in which the opening, when small and in the most dependent portion of the pouch, has been left to itself. Cases where the whole of the anus is removed and the wound is left to drain itself do better than those in which an attempt is made to save the sphincter and drain the wound with tubes. By trying to save too much, life may be lost. The mortality of the operation itself is rather over thirty-three per cent., death being generally due to retro-peritoneal suppuration characterized by acute septic symptoms. The attempt to bring down the upper end of the bowel and stitch it to the skin to form a new anus is generally not attended with any good result. In a small proportion of successful cases there will be complete incontinence after the operation; in a greater number there will be partial control of the evacuations; and in the majority the control will be sufficient to prevent the occurrence of any unpleasant accidents. Stricture to an annoying extent will sometimes be encountered as a result of the cicatrization, and must be overcome by dilatation.

When the disease is circumscribed so that it can be entirely removed, and when it does not reach so high as to necessitate the opening of the peritoneum, this operation may be indicated; in other cases the risk of an immediately fatal result overbalances the advantages to be gained by its performance. It is chiefly valuable as a palliative measure, and that it ultimately prolongs life has not yet been established. A few cases have been reported in which the disease has not returned for five or six years; but many patients have lived longer than this without any operation. The disease generally reappears within the first year after operation, and is fatal within two. In cases properly chosen, where the disease is not so extensive as to render its removal one of the most dangerous of the capital operations, the complete or partial excision of the growth is one of the best known methods of palliative treatment. The pain will be greatly relieved, the obstruction overcome, the discharge decreased, and the general health will be correspondingly benefited. Most of this improvement may be gained by the single, deep, posterior incision, without much excision; and proctotomy, as a palliative measure, is less dangerous than excision and fully as effectual. My own favorite practice is to combine proctotomy with partial extirpation, except in cases where the disease is so circumscribed as to render its entire removal easy. The growth, when too extensive for removal, may be attacked with the knife, cautery, finger, or curette, and sometimes greatly reduced in size. Considerable pieces may sometimes be removed with the wire écraseur, and Simon's sharp scoop is a very effective and useful instrument. The passages should be kept soft but not fluid, as any approach to diarrhœa always aggravates the suffering. This may be done partly by the choice of food, which needs to be regulated with great care, and should be of that kind which gives the greatest nourishment with the least detritus. An occasional laxative in the form of one of the mineral waters may serve a good purpose. Rest in the recumbent posture will sometimes give greater relief to pain than anodynes. These latter may be given both by the mouth and in enemata, and, if possible, should be pushed to the point of relieving suffering. Unfortunately this cannot always be done. Lumbar colotomy as a palliative measure is only applicable to those cases which are too high up to be reached from the rectum. It can do nothing but relieve pain and prevent obstruction, and in relieving pain it is limited to those cases in which such pain is due to the direct contact of fæces with the disease. This is only one of the causes of pain in cancer, and one of the least. Most of the suffering is due to pressure, and will be as great after colotomy as before. Moreover, some fæces will always be found in the rectum, even after the establishment of an artificial anus.

The operation of excision has, with the recent advances in abdominal surgery, also been applied to cancer of the sigmoid flexure and descending colon. This operation, to which the name of colectomy has very properly been

Anus and Rectum.

given, has now assumed a definite place in surgery, and there are ten cases of it on record. Five have been immediately fatal from the operation itself, and in five the patient has recovered. Of these, two died in seven months, one in ten months, one was alive two years later, the history of one ends with the recovery from the operation, and the last one reported was alive when the case was published, soon after the operation. In deciding upon the propriety of this operation in any particular case, it would seem advisable to consider how long a life the patient is likely to have if not operated upon. For example, it would hardly seem good surgery to subject a patient to an operation the immediate mortality of which is fifty per cent., and then have him die of a recurrence of the disease in seven months, when he might have lived seven months without any operation. The amount of actual obstruction caused by the disease must in many cases decide the propriety of surgical interference. In cases of obstruction where the symptoms point toward this part of the bowel, even when the diagnosis is not certain, it may be well to make an exploratory incision in the left groin instead of in the median line, having in mind the possible extirpation of the disease and the establishment of a new anus at this point. It can at least be said that in cancer of the descending colon, sigmoid flexure, and upper part of the rectum, when the disease is still movable and has not invaded too much of the tissue around the bowel, an attempt at its removal is justifiable; and in cases of intended colotomy it may be found possible after the incision has been made to substitute colectomy for colotomy. This is another good reason for substituting the inguinal for the lumbar incision in colotomy, though it is perfectly possible to extirpate the disease through the loin. The result of the operation undoubtedly depends in a great measure upon the certainty with which the diagnosis is made; or, in other words, upon the exact adaptation of the operation to the end to be attained. In most of the successful cases, the diagnosis as to the seat and nature of the obstruction was made before the operation was begun, and in all of them only a single incision was necessary to reach the tumor. In three of the five fatal cases two incisions were made—one in the median line for exploration, and subsequently a second one to reach the disease. There seems to be little difference in the mortality whether the ends of the divided intestine be united and the abdominal wound closed, or one end be brought to the surface for the formation of an artificial anus. The latter is the simpler method; the former gives the better result. A great difference in the size of the two ends will sometimes render their union difficult; the upper being frequently hypertrophied and dilated, the lower contracted.

NON-MALIGNANT GROWTHS.—Under this head may be included polypus, vegetations, condylomata, and the rarer examples of benign fungus, gummata, ano-rectal syphiloma, fibroma, lipomata, and the various forms of cysts.

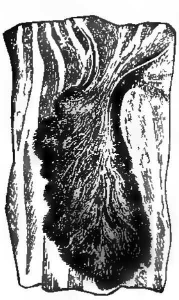


FIG. 219.—Soft Polypus. (Esmarch.)

Polypus may be defined as a benign tumor composed of one or more of the normal elements of the rectal wall; an hypertrophy either of the mucous membrane or of the submucous connective-tissue. The former is generally spoken of as soft or villous, and the latter as hard or fibrous. The former is shown in Fig. 219, and is often spoken of as the polypus of childhood; the latter is known as the polypus of adults, though these distinctions are of little practical value.

A polypus of the soft variety may reach the size of a pigeon's egg, is soft to the touch, may break down under the finger with rough handling, and has a shaggy or cauliflower surface. On section the surface is grayish-red, the substance homogeneous, and the fluid forced from it by pressure will be found full of cylindrical epithelium. A microscopic examination shows it to be composed of long, fine, bifurcated papillæ, covered with cylindrical epithelium. The glandular or adenomatous polypus (Fig. 220) is generally the size of a small plum, rarely that of a pear, and yet may reach a weight of four pounds. It is vascular, and therefore of reddish color; sometimes smooth on the surface, but often mammillated, like a strawberry; attached by a pedicle, generally to the posterior wall at a point within reach of the finger; and may be found anywhere between the ileo-cæcal valve and the anus. It is due to an hypertrophy of either the follicles of Lieberkühn or the closed follicles. There is another variety of polypus which is formed by an hypertrophy of both the villi and the follicles of Lieberkühn, and is known under the various names of villous polypus, villous tumor, granular papilloma, and "peculiar bleeding tumor." These tumors are very rare, have the feel of a large warty polypus with cauliflower surface, are of red color, bleed easily when touched, and are of relatively slow growth. They adhere to the rectum by a pedicle, sometimes composed chiefly of mucous membrane, and at others large, short, and fleshy. The pedicle may be absent and the growth will vary in structure according to the proportions of its different elements. It may reach the size of an orange, is found only in adults, and the symptoms are the same as those caused by other polypi.

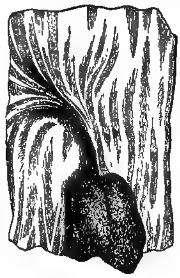


FIG. 220.—Glandular Polypus. (Esmarch.)

The hard or fibrous polypus (sarcomatous polypus), which is composed primarily of the elements of the submucous connective-tissue, is much rarer than the soft variety, and is most commonly found in adults, where it may be single or multiple. It is composed chiefly of fibrous tissue, and resembles the uterine fibroid; but it may contain both muscular and glandular elements. They vary greatly in the degree of hardness to the touch, according to their composition and turgescence. They may creak under the knife on section and look very much like hypertrophied and œdematous skin; or may resemble the better-known nasal polypus in composition. When seen in the rectum before removal the surface is generally red from vascularity; but after removal they are pale and generally smooth, though sometimes uneven and irregular in surface and covered with hypertrophied papillæ. The mucous membrane is generally easily stripped off, unless there has been local inflammatory action, in which case it may be firmly attached and have lost its natural appearance. The vascular supply is abundant, both in the substance and on the surface of the tumor. The pedicle is generally slight, and is formed mechanically by the traction of the growth. The tumor is benign in character, and when once removed does not generally return, though cases of recurrence at or near the same point are not unknown.

A rectal polypus may exist many years and give no signs of its presence. The two chief symptoms which it is apt to excite are hæmorrhage and discharge. The former may be of daily occurrence, or may be present only at long intervals, and it may vary in amount from a few drops to a quantity which shall cause grave disturbance and alarm. When the mucous membrane covering the tumor has once become ulcerated, the bleeding will be frequent and the discharge more or less fetid. When the tumor is so high and the pedicle so short as to be beyond the grasp of the sphincter, there will be little or no pain; but after prolapse once begins to occur, the suffering at each act of defecation may be extreme. The sphincter may become dilated and relaxed, or if it remain strong it may work a spontaneous cure by strangulating the pedicle. The discharge is sometimes profuse and constant, escaping not only at the time of defecation but at frequent intervals between, and being of an exceedingly fetid character. This by its irritation may set up secondary troubles, congestion of the mucous membrane, erosions around the anus, vegetations, diarrhœa, and

tenesmus, and joined with the loss of blood the condition may be mistaken for extensive ulceration or malignant disease.

When a polypus presents at the anus it should easily be diagnosticated, and should not be mistaken for hæmorrhoids. Hæmorrhage from the rectum in a child usually indicates polypus, and it often means the same in an adult, though it will oftener indicate hæmorrhoids. In making a digital examination an enema should first be given, and the finger should be introduced, while the rectum is filled with water. In this way the polypus will float freely in the distended pouch. The finger should be passed up along the anterior wall and brought down along the posterior, so that the pedicle may be put upon the stretch and the tumor caught in the descent. If the opposite rule be followed, the tumor may easily be carried up on the finger and escape detection. In some cases of sarcomatous polypus, with broad attachment, the diagnosis between benign and malignant tumor may be difficult to make, even with the microscope.

The treatment is generally simple. When the pedicle is long and slender the tumor may generally be safely twisted off, but it is better to apply a ligature. There are two dangers to be considered; the first is that the pedicle may contain large vessels, and the other is that it may contain peritoneum. The extirpation of a polypus which came down from the sigmoid flexure and dragged the peritoneum with it has been followed by death. Should there be a large, fleshy pedicle it must be securely ligatured.

The anus and adjacent skin are often the seat of vegetations of a warty or papillomatous nature, due to a simple hypertrophy of the papillary layer of the skin. They are composed of the connective-tissue, the epithelial covering, and the blood-vessels, which in their natural proportions and quantities make up the papillæ of the derma. These little tumors resemble ordinary warts. When one of them is isolated it is dry, but when several of them are united they become macerated in the secretion of the part which decomposes between them, and gives rise to inflammatory phenomena. The tumor then becomes moist and fetid, and all the adjacent parts become irritated. According to the number and size of the warts, the condition of the patient, the abundance of the secretions, and the irritation to which they are originally due, these vegetations take on various shapes, and hence have been described as cock's-combs, cauliflower excrescences, etc., but the elementary structure of all of them is the same. They were formerly considered as proof positive of syphilis, and even of sodomy, and were so treated; but they have nothing to do with syphilis, and they owe their growth in the first place to a special predisposition to the formation of warts in the individual, and, in the second place, to the presence of some irritating cause acting on this particular part. Thus the discharge from any disease of the rectum or genitals may cause them to grow, and they may appear in persons apparently perfectly healthy and cleanly. Pregnancy has an undoubted influence on their production, and they may disappear spontaneously after delivery. They may appear at any age from infancy to adult life, though generally belonging to the latter. They may vary in size and quantity, from a single enlarged papilla to a mass weighing a pound. When they grow from one side of the intergluteal fold, and are large enough to press with their moistened surface upon the corresponding point on the opposite side, a second patch may be developed at the point of contact. Their development may be slow or rapid, and when they reach a large size the patient is troubled by the feeling of a foreign body, by a sanious and foul discharge, and by fresh erosions and superficial ulcers in adjacent parts. Great pain in defecation may be caused by a small wart just at the verge of the anus, and such a little tumor may cause all the symptoms characteristic of fissure; they may also spring entirely from the mucous membrane above the sphincter. There is little danger of mistaking a mass of these warts for a malignant growth, though they have been known to assume a semi-malignant character, and to return frequently after removal. The most common error is to consider them as syphilitic condylomata, and indeed they may not always be easily distinguishable from the raised mucous patch or flat condyloma which is a manifestation of true syphilis. The two may exist simultaneously, the former caused by the irritation of the latter.

The surest, most rapid, and in every way most satisfactory method of curing these warts is to simply cut them off with the knife or scissors. The ligature is not always applicable, and cauterization is apt to do more than is necessary. The growths may, however, be induced to dry up and shrivel away by applications of powdered alum or tannin, and by washing with astringent lotions, such as Labarraque's solution.

The term condyloma has been applied to so many different growths around the anus that it has lost all definiteness. The variety of syphilitic mucous patch situated upon the skin near the anus, and known as condyloma lata, or vegetating condyloma, first manifests itself as a red spot, and by a slight effusion beneath the epidermis, which is soon rubbed off by friction, exposing a raw surface generally covered by a grayish pellicle. This surface is subsequently elevated by an upward growth, and by branching of the papillæ, with formation of connective-tissue and dilatation of the blood-vessels. Where this process has reached a considerable extent, a cauliflower appearance is the result, and what was at first a simple mucous patch may become a large, pedunculated, warty growth surrounded by other vegetations which have sprung up around the original lesion, and which are due to the irritation of its presence.

The more general meaning of the word condyloma is, however, a non-syphilitic tumor composed of an hypertrophy of the skin around the anus, attached by a broad base, pinkish in color, soft, fleshy, glistening, moist, irregular in shape, flattened where two are pressed together, and generally giving out a slight secretion. These tumors generally have one of the radiating folds of the anus as their point of departure, and they differ from the warty growths in the fact that they consist of an hypertrophy of the whole thickness of the skin and not alone of the papillæ. The epithelial element in them is not as marked as in the warts, and the blood-vessels also are less developed. They are merely the result of a localized chronic inflammation of the skin, and often result from an external hæmorrhoid or any local irritation, such as has already been spoken of. They are a very common accompaniment of any ulcerative process within the rectum, and hence of stricture, and many a stricture has been unjustly stamped as syphilitic because the discharge from the anus has caused the development of these fleshy tags. Unless there is some special reason for interfering with them they may generally be left to themselves, as they are not likely to cause any amount of trouble unless they become ulcerated upon the surface. In this case they are easily removed by the scissors and ligature.

Pruritus Ani.—Itching at the anus is generally a symptom of some other disease, as hæmorrhoids or eczema, but it is often present in a marked degree when no cause for its existence can be discovered. It is an exceedingly painful and annoying affection, which seems to be dependent upon no particular general state, being found in all classes. The itching is more or less constant, but is generally worse after the patient has become warm in bed for the night. The scratching which is indulged in for relief, often unconsciously during sleep, aggravates the condition by lacerating the skin. The disease is sometimes, in old cases, attended by marked changes in the appearance of the parts. The skin becomes thickened and parchment-like, or else eczematous and moist from exudation, and there may be a very characteristic loss of pigment, in which case the skin becomes of a dull-whitish color. This is particularly noticeable in cases of long standing. Associated with this condition it is not unusual to find one or several fissures.

The causes of pruritus are sometimes easily discoverable, and in such cases a cure rapidly follows their removal. It is often due to internal hæmorrhoids, and will be effectually cured by their removal. It is often a symptom and complication of a fistula with a small ex-

Anus and Rectum.

ternal opening, which is easily overlooked, and may be relieved by the cure of the latter and the cessation of the discharge. It is often dependent upon the presence of worms in the rectum, and in every case these should be carefully looked for. When they exist they may generally be seen like a small piece of fine, white thread between the radiating folds at the verge of the anus, especially at night after the itching has begun. Instead of a parasite within the rectum the disease is sometimes easily accounted for by the presence of pediculi. Again, pruritus of an intense kind may be due to *eczema marginatum,* and the diagnosis will rest upon finding the spores of the plant under the microscope; or it may be a symptom of a chronic eczema, of herpes, or of erythema. When no local cause can be discovered a constitutional one should be carefully sought for, and a careful inquiry must be made into the patient's general health and habits. If chronic constipation be present it must be overcome first of all. In women the condition of the generative organs must be looked after, and the urine should be examined for sugar.

In case none of these causes can be found to account for the symptom, errors of diet must be searched for and corrected. Anything like excess in smoking or alcohol will aggravate the disease, and these habits must be carefully regulated if indulged in at all. The disease will sometimes be encountered in stout, full-blooded persons who live well, and perhaps incline to gout. In such, active exercise and plainer living, with cold bathing of the part night and morning, and the use of a wash containing tar or carbolic acid, will often effect a speedy cure. On the other hand, the disease may be present in persons of exactly the opposite class, the overworked and worried professional or business man, and in this class of cases alone, where the itching seems to be a purely nervous affection, arsenic is indicated. It may be combined with quinine and cod-liver oil, and carried to its full physiological effect. If pin-worms be the cause, they may generally be removed by certain simple measures, the best known of which is an enema of lime-water, or of carbolic acid, ʒ j.; glycerine, ℥ j.; and water, ℥ vij., injected after each passage. Turpentine and tincture of iron used in the same way are very effectual. The most effectual remedy for eczema marginatum is a wash of equal parts of sulphurous acid and water, frequently applied with a soft cloth, and, when necessary, gradually increased in strength up to the pure acid, which is, however, a painful application, and one which will readily blister. Strong tincture of iodine, thoroughly applied, is also an effectual application. If there be thickening of the skin from effusion, the application of very hot water freely with a sponge may give relief, and if a stronger application be necessary, the compound tincture of green soap, or a solution of caustic potash (gr. v. to ℥ j.), or liquor potassæ may be resorted to. A good ointment is made of the ordinary oxide of zinc, made soft and applied gently, and one which is very effectual in temporarily allaying the itching is made of chloroform (ʒ j. to ℥ j.). Another effectual application is composed of carbolic acid, ℥ ss.; glycerine, ℥ j.; and water, ℥ iij. This may be applied at night, and its strength may be adapted to the case. There are many formulæ of this kind, all of which answer a good purpose, but the cure is to be undertaken in a broader spirit than by searching for any single ointment or lotion which will allay the itching for a time. In every case the cause must be found and removed if a permanent cure is hoped for. If undertaken in this way and intelligently treated by both doctor and patient, a cure may generally be effected, sometimes in a very few days, but at others only after many discouragements.

Spasm of the Sphincter.—This is an affection which has been much disputed about, but which undoubtedly sometimes exists alone, and without any complicating fissure. It is generally found in nervous and debilitated patients; and its symptoms are more or less uneasiness about the anus, a sense of fulness in the perineum, often more or less difficulty in micturition, constipation, and pain and difficulty in defecation. A digital examination will often show a markedly contracted anus, and an attempt to introduce the finger will cause unbearable agony. The act of defecation may be exceedingly difficult to accomplish on account of the pain it causes; and any anxiety or distress of mind, and anything which tends to irritate the rectum or the parts around will aggravate the difficulty. The treatment consists in attention to the general health, in allaying nervous excitement, in the administration of laxatives to relieve the bowels, and in anodyne injections, such as twenty drops of laudanum. The surgical treatment consists in etherization and thorough dilatation of the sphincter. If this cannot be done, the next best thing is the systematic use of bougies.

Neuralgia.—This is an affection which, like the last, is most often seen in nervous people, particularly women. The pain is apt to be paroxysmal but may be continuous, and, unlike spasm, is entirely independent of the act of defecation. It is much the same disease as neuralgia elsewhere in the body, and must be treated in the same general way. Where there is well-marked periodicity a malarial element must be looked for; and the disease is sometimes the only manifestation of the gouty diathesis. In all other cases the treatment must be the same as for neuralgia elsewhere in the body, and will be attended by the same results. The first care should be for the general health, the second for the regularity of the bowels, and after this local applications of cold water, ointment of belladonna, and blisters over the sacrum may be tried. The disease must be carefully distinguished from coccygodynia and from spasm of the sphincter.

Congenital Malformations.—In the fœtus the anus is at first represented by a simple depression in the skin of the perineum which gradually extends in depth and advances to join the rectum. The rectum is developed in connection with the abdominal viscera, gradually separates itself from them, and, ending in a blind pouch, advances to meet the anal depression. The process of development may be arrested at almost any stage, and the result will be one of the malformations to be spoken of. These have been variously classified:

1. Narrowing of the anus or rectum without complete occlusion. The stricture in these cases may be very slight, or may reach such a degree as hardly to permit the passage of meconium. It is generally linear, resembling the constriction which would be caused by tying a tape around the tube. There may be no symptoms caused by this condition, and the child may grow to adult life suffering only from constipation. Such strictures do not cause the secondary changes above and below which attend those of acquired origin. When the stricture is tight it will give rise to the usual symptoms in the child—absence of passages of meconium, distention of the abdomen, and vomiting. The contraction will generally be found near the anus, and the diagnosis and treatment are, therefore, easy. The latter consists either in dilatation or nicking.

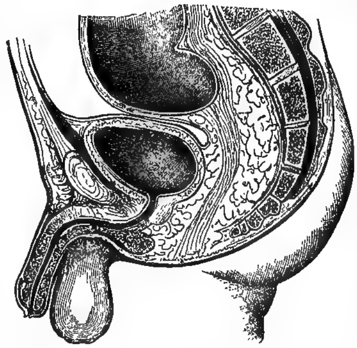


Fig. 221.—Rectum ending in a Blind Pouch. (Mollière.)

2. Closure of the anus by a membranous diaphragm. The membrane in these cases may be of greater or less firmness and thickness, and may be composed of skin or of mucous membrane. It is sometimes so thin as to bulge out with the pressure of the meconium when the child strains or coughs, and has been known to rupture spontaneously. It is the simplest of all the varieties of malformation, and one of the rarest. The treatment consists in a crucial incision through the membrane, which will then shrivel away.

3. Entire absence of the anus, the rectum ending in a blind pouch at a point more or less distant from the perineum (Fig. 221). In these cases there may be a slight depression at the point where the anus should be found, or there may be no trace of the anal orifice, the *raphé* of the perineum extending over the spot in an unbroken line. The external sphincter is also sometimes present, and at others entirely wanting. The pouch of the rectum may hang loose in the pelvis or abdomen, or may be attached to some adjacent part; and the space between it and the perineum may be filled in with cellular tissue, or a distinct fibrous cord may be traceable from the rectal pouch to the skin. If the rectal pouch be not at too great a distance from the skin, fluctuation may be obtained by one finger over the perineum and the other hand on the abdomen. Valuable aid to diagnosis may be obtained by placing one finger in the vagina. A careful examination should always be made to see that the rectum does not communicate with the vagina or bladder.

FIG. 222.—Rectum ending in a Blind Pouch; Anus Normal. (Mollière.)

4. The rectum may be the same as in the last variety, and the anus normal (Fig. 222). The septum separating the anal and rectal pouches in these cases is generally within easy reach of the finger, and may be so thin as to permit a sense of fluctuation. It is composed of cellular or fibrous tissue lined both above and below by mucous membrane. It may be perforated like the hymen at some point, and allow a slow dribbling of meconium; and there may be more than one septum.

In addition to these more common malformations there are various others. The anus may be absent and the rectum may open by an abnormal anus at any point in the perineal or sacral regions, or it may end in the bladder (see Fig. 223), urethra, or vagina. The rectum and anus may be normal but the ureters, uterus, or vagina may communicate with the rectal cavity and discharge their contents through it. The rectum may be totally deficient, as may also be a large portion of the large intestine. In these cases the anus is also generally absent and its place supplied by an outlet at the umbilicus or some remote part of the body, as the side of the chest.

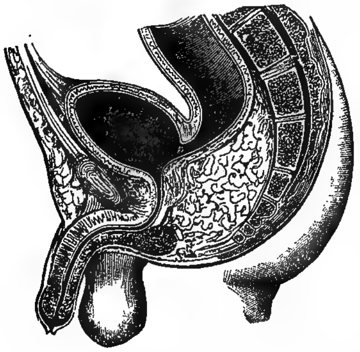


FIG. 223.—Rectum ending in the Bladder. (Mollière.)

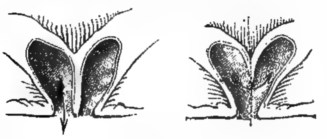
There are a few general rules which should govern the treatment of these cases. Some of the varieties last described are beyond the reach of surgical aid, and the treatment of the first two classes has been mentioned. In the others an operation should always be performed, and without delay. There is little to be gained even by waiting for the rectum to become distended with meconium, and there is much to be lost. If the obstruction be complete and unrelieved, death will follow either from peritonitis, rupture of the distended bowel, or gradual wasting away without acute symptoms. Even in cases where a certain amount of meconium escapes by a narrow orifice, nothing is to be gained by delaying the operation. If there be any chance of establishing an opening at the normal site of the anus, the surgeon should first try this procedure; and since in most cases it is impossible to tell that the rectal pouch may not be within easy reach from the perineum, it is generally good surgery to make a tentative incision at this point. The means at the surgeon's disposal consist of puncture, incision, and incision combined with a plastic operation for the formation of a new anus. The operation by puncture consists in plunging a trocar through the perineum in the supposed direction of the rectum for the purpose of establishing an outlet. It may be done without a preliminary incision, or after a careful dissection has failed to reach the desired point. The use of the trocar as an aid in finding the rectal pouch, even after a careful dissection in the perineum, is not a justifiable operation. It is attended by the greatest danger to the life of the patient, and when the rectal pouch is successfully reached by it, which is very rare, the outlet thus made is of little use. The peritoneum, bladder, or uterus may each be wounded by the instrument, with a fatal result, the opening is not free enough to allow of even the easy escape of meconium, nor can it be made to serve the purpose intended by subsequent dilatation.

The results of attempts to establish an outlet by means of incisions alone through the perineum are not favorable as regards a useful anus; for the operation, though it may be immediately successful in allowing the escape of meconium and prolonging life, does not in most cases result in a useful anus for any great length of time. This operation may, however, be modified in two important particulars and thereby rendered much more efficient. The rectum may be drawn down from above and stitched to the skin, and to facilitate this where it is too short to reach the surface of the perineum at the proper point, the new anus may be made just at the tip of the coccyx, or that bone may be removed entirely and the anus be made to occupy its place. In case of failure to establish a new anus in the anal region, colotomy should be at once performed. The teaching of different authorities will be found to vary as to the propriety of first performing a perineal operation before resorting to colotomy. Some follow the rule I have laid down, that it is always better to attempt the perineal operation where there seems to be the slightest chance of its succeeding; others limit the latter operation to cases where the rectal pouch is known to be near the skin, and in all others turn their efforts at once toward the colon. In the formation of an artificial anus the left groin is the best site for the operation. In children the mesocolon is so lax that the sigmoid flexure may wander even across the pelvis. He who attempts the lumbar operation in a child may consider himself fortunate if he finds the desired point at all; and when found, it is so completely surrounded by peritoneum as to render a wound of that membrane almost a certainty. The operation in the groin is much easier of performance, and the resulting anus much more easily cared for by the patient. These facts, together with the decreasing fear of wounding the peritoneum, have led surgeons to advocate the inguinal operation in all cases for which the lumbar incision has generally been made.

An incision about two and a half inches long is made in the left groin parallel with Poupart's ligament, about half an inch above it, and well toward the lateral wall of the abdomen—so far that the epigastric artery should not be seen in the operation. This incision is carried down to the peritoneum, each successive layer being divided on a director. Before the peritoneum is opened, all hæmorrhage from the wound should be stopped and the cut rendered as dry and clean as possible. The peritoneum is then pinched up with forceps and nicked, a director is introduced, and the opening enlarged to the extent of an inch and a half. The descending colon should be in view immediately below the wound, and is recognized by the usual signs. When such is the case the subsequent steps in the operation are comparatively simple; but when not the case the bowel must be searched for and, if necessary, the incision must be enlarged. The operation may be modified to advantage by stitching the parietal and vis-

ceral layers of the peritoneum together with sutures passing down to the submucous coat of the bowel but not into its calibre. The wound may then be covered and the opening of the bowel delayed for a few hours till adhesions have occurred.

Attempts at establishing an anus in the perineum after the performance of colotomy are attended with great danger, and are generally unsuccessful. Dr. Byrd,[2] however, has made some very ingenious and successful operations for this purpose. It is well known that after colotomy the side of the bowel away from the opening becomes sharply bent upon itself, as shown in Figs. 224 and 225. The septum must be destroyed before the artificial anus is closed, and this is accomplished by compressing it between the blades of a pair of forceps till it sloughs. The essential points in Byrd's operation are the passage of a director down the bowel from the new opening to the bottom of the pouch, and then cutting down upon this as a guide from the perineum. After forming the anus in the perineum the artificial opening is closed by a plastic operation of his own devising.



FIGS. 224 and 225.—Condition of the Bowel after Colotomy, showing Septum and Course of Fæces. (Packard.)

Charles B. Kelsey.

[1] Arch. of Dermatology, January, 1876.

[2] "Lumbo-colotomy in the New-born for Relief of Imperforate Rectum." Read before the Tri-State Med. Soc., St. Louis, October 25, 1881. Reprint.

AORTA. The aorta (ἀορτή, *arteria magna*) is the largest artery in the body, although its calibre at its commencement is sometimes smaller than that of the pulmonary artery. It commences at the left ventricle of the heart and terminates at the left side of the body of the fourth lumbar vertebra, where it divides into the right and left common iliac arteries. It does not, however, pass directly between these two points, but first rises into the chest for a distance of about two inches, and there forming a more or less regular arch passes downward to terminate as before designated.

The aorta may, for purposes of convenience, be described as consisting of three portions—the arch, the thoracic aorta, and the abdominal aorta. Of these, the arch is the first division ; it is composed of three portions—the ascending, the transverse, and the descending.

The ascending portion of the arch is given off from the upper part of the left ventricle of the heart, a point which corresponds to the left border of the sternum on a line midway between the costo-sternal articulations of the third and fourth ribs. It passes upward and to the right as far as the junction of the second costal cartilages with the sternum upon the right side, where it changes its direction, becomes the transverse portion of the arch, and, passing from right to left and from before backward, it reaches the left side of the body of the third dorsal vertebra ; here, where it makes rather an abrupt curve, the descending portion of the arch commences, which again proceeds as far as the lower border of the fourth dorsal vertebra to become continuous with the thoracic aorta, as the remaining part of the artery within the chest is designated, in contradistinction from the arch.

This thoracic aorta extends as far as the diaphragm, passes through an opening in it, and, emerging into the abdomen, receives the name abdominal, which it retains to its termination.

The aorta at its commencement lies about an inch and a half behind the sternum ; it presents at this point the openings of the two coronary arteries and three dilatations known as the sinuses of Valsalva. It is covered by the pericardium for a distance of two inches, and the line of attachment of this membrane serves to mark the boundary between the ascending and transverse portions of the arch. The transverse portion is about three inches in length, and its highest part lies about one inch below the upper margin of the manubrium ; from it arise the three large arterial branches which supply the head, neck, and upper extremities, namely: 1, the arteria innominata ; 2, the left carotid artery ; 3, the left subclavian artery. From the third or descending portion of the arch no branches are given off, and it is held snugly in position by its attachment to the dorsal vertebræ.

The thoracic aorta follows the curve of the spinal column ; at first it is situated upon its left side, but as it descends it gradually approaches the median line and at the last dorsal vertebra lies in front of the spine. Its branches are small ; they are : 1, pericardial ; 2, bronchial ; 3, œsophageal ; 4, post-mediastinal ; 5, intercostal —ten pairs.

The abdominal aorta at its commencement lies, as does the termination of the thoracic aorta, directly in front of the spinal column ; as it descends it passes again to the left of the vertebræ, so that at the fourth lumbar vertebra, where it terminates, it has again reached its original position to the left of the spine. The branches of the abdominal aorta are large, numerous, and important. They are the (1) phrenic ; (2) cœliac axis (gastric, hepatic, splenic) ; (3) superior mesenteric ; (4) suprarenal ; (5) renal ; (6) spermatic ; (7) inferior mesenteric ; (8) lumbar ; (9) sacra media.

Wyeth's measurements give the circumference of the aorta at the sinuses of Valsalva as four inches ; just above this is a constriction where it measures only three and a half inches ; but at a point two inches from the ventricle the circumference is greater than that of the sinuses. The descending portion of the arch is much smaller, from the departure from it of the three large branches of the division before it. The distance (Wyeth's measurements) from the origin of the arteria innominata is 3.48+ inches. The distance from this artery to the next branch, the left carotid, is .43+, and from this last named artery to the left subclavian the distance is .79+ inch. The thoracic aorta does not diminish greatly in calibre, because its efferent vessels are comparatively small ; but from the abdominal portion spring so many large and important arterial trunks that at its termination its diameter is not more than one-half that of the aorta at its commencement.

The structure of the aorta is in general the same as that of the other arteries. Its middle coat is, however, proportionately and actually thicker, and possesses a relatively larger amount of elastic tissue and a smaller amount of muscular tissue than do the other arteries.

The aorta is of all arteries the most liable to disease. Aortitis, acute and chronic, atheroma and calcification are frequent.

It is also the favorite seat of aneurism. Of 703 cases collected by Sibson the situation of the aneurism was distributed as follows : ascending portion of arch, 193 ; ascending portion of arch and transverse arch conjointly, 140 ; transverse arch alone, 120 ; transverse arch and descending arch conjointly, 20 ; descending arch, 72, thoracic aorta below the arch, 71.

William L. Wardwell.

APHASIA, AGRAPHIA, AMIMIA. Aphasia (ἀ, negative, and φάσις, speech), signifies impairment of the idea of language or its expression.

This abnormal cerebral condition shows itself in various degrees of intensity, from sluggishness of speech or disorderly articulation up to incoherence of ideas and total abolition of the power to express thought, either by speech, gesture, or writing. The function of expression may be arrested, perverted, or destroyed, and may include in varying proportions the loss of memory for words ; the loss of power to express ideas by written signs or by gestures, and an intellectual disturbance that may overthrow the verbal part of the mind and cause wreck and ruin of the faculty of language.

Technical names for the foregoing conditions having been applied and used from time to time in accordance with certain etymological and pathological notions, the terminology of dysphasia is somewhat mixed. Hellenic

authority rejecting *alalia* as too comprehensive and susceptible of several explanations, suggests such terms as *aphthongia*, *aphthenxia*, *aphrasia*, and *aphemia* to indicate the impaired expression of articulate sounds; while *agraphia* or *paragraphia* and *alexia* imply a loss of comprehension of written language, which is far more common in aphasiacs than that of articulate language. *Dysmimia*, *amimia*, and *paramimia* signify disturbances in the manifestations of ideas by gestures and by variations of the physiognomy. In order to gain a more accurate terminology *asymbolia* and *asemia* have been proposed as more comprehensive. Cortical derangement of speech proceeding from impaired intellect is known as *dyslogia* or *alogia*, and further refinements are found in *agrammatism* and *akataphasia*, which signify inability to form words grammatically and to arrange them syntactically.

These words have been used in late years to designate the various degrees of impaired expression, but as a matter of medico-historic interest it may be said that recorded notices of defects of expression are not so new, having been mentioned in antiquity, the middle ages, and the last centuries. In both the Iliad and Odyssey, Homer speaks of a temporary loss of speech resulting from strong moral emotion. Similar passages occur in Euripides, Thucydides, Plato, and Apollonius of Rhodes. Pliny mentions a disorder of memory in which the symptoms are those now known as amnesic aphasia. Hippocrates, it is evident from his remarks on the subject, did not difference the symptoms of aphasia from those of aphonia. Most remarkable in connection with the subject are two passages of Sextus Empiricus in which the word ἀφασία is not only mentioned, but defined with great care in its philosophic sense, which does not differ sensibly from its pathological sense.[1]

Toward the end of the sixteenth century aphasic derangements attracted the attention of Schenkius, and later Van Swieten, Cullen, and others; but it was not till 1836, when Dr. Marc Dax communicated his celebrated paper to the meeting of physicians at Montpellier, that the knowledge of the subject began to take scientific form. He seems to have been the first to recognize the concurrence of derangements of speech with lesions of the left half of the brain, but the treatise excited so little attention as to remain in obscurity till 1863, when the subject of cerebral localization led to long and important discussions before the French Academy. This memorable discovery of Dax having placed the matter in a new light furnished the motive for numerous essays, a mere outline statement of which it is not necessary to give. Attempts toward cerebral localization may therefore be regarded as of French origin, notwithstanding the unscientific and phrenological attempts of others to locate the faculty of speech.

Since no complete and satisfactory explanation of the phenomena of the impairment of the function of expression in aphasia has been given, it seems proper that a study of the normal laws of language should precede the inductions of anatomy and pathology, and this, too, without going out of the domain of medicine. In a generic sense, language includes the expression of ideas and emotions by articulate speech, graphic representation, and indicative gesture, or in other words, all the "representative signs of ideas." Language extends to all forms of manifestation of thought, and requires the whole range of the nervous centres, mental, sensory, and motor in its elaboration, although the concurrence of these numerous elements in the manifestation of thought is, in fact, nothing more than a co-ordinate movement that we do every day in other acts equally complex, such as standing, walking, or playing on a musical instrument. It is generally acknowledged by philologists that there is an intimate and necessary relation between thought and language, and that mental language is absolutely indispensable to thought. Physiology recognizes the fact that it is more intimately associated with ideation than other muscular acts. The natural and elementary language of man, common to all races, is seen in the varied and mobile expression of the physiognomy, which is often as eloquent as speech itself. Observant men of travel soon learn the meaning of looks, tones, and gestures, not only among uncivilized tribes but among themselves. This is a vernacular or a congenital reflex that exists among the most distinct races of men from infancy, and does not require to be learned.

The author of the "Descent of Man," speaking of the close similarity between men of all races in tastes, dispositions, and habits, adverts to the mutual comprehension of gesticulatory language by the same expression in their features, and by the same articulate cries, when excited by the same emotion, and he further remarks that this is not so with distinct species of monkeys. The articulate cries by which animals express themselves differ in two important particulars from the faculty possessed by man of giving body or form to his thought. To clothe it with a sensible sign, which permits of its being outwardly construed or interpreted, the two additional elements of reason and of speech are necessary to obtain the result. One is purely intellectual, the other essentially mechanical. The conditions give rise to conventional signs which are produced after uniform laws, and have a certain stamp of conventional mobility. Human language is composed of abstractions representing not only outward objects but ideas created by the mind. The faculty that produces mere words and phrases is not alone concerned in speech: memory, the faculty of abstraction, comparison, association of ideas, etc., produce an intellectual co-ordination resulting in thought spoken mentally, or the interior language indispensable to formulate thought by representative signs. It would be trespassing on the linguistic and psychological domain to discuss the origin of speech and the onomatopoetic feeling of children. To the student of nerve-physics, the genesis of ideas and conception reflexes is of less consequence than a consideration of the impulse that prompts the child to mimic the speech of others, and thereby acquire as an inheritance the ready-made or artificial language by which he expresses his thoughts and feelings. This artificial language, by means of which we express our ideas, being governed by the laws of convention, is forced and transitory; the language established by nature is universal, spontaneous, and fixed. The borrowed language of stage action and the mimicry of actors, singers, and pantomimists belong to the artificial class, and differ from the natural manifestations of thought expressed by movements of the body, varied attitudes, or by cries. Whatever be the mode of expression, whether mimic, spoken, written, or figurative, the three indispensable physiological conditions of language, namely, a cerebral impulse, an intermediary organ to transmit, and muscles to execute, must always be present in the normal condition. At different stages in the elaboration of language these functions are more or less impaired, giving rise to the numerous defects of expression comprehended under the useful and generic term aphasia.

The symptoms are present under two forms: abolition of the faculty of language with preservation of memory; and abolition of the faculty of language and of memory. In the first form, known as ataxic aphasia, the function of articulation is lost or perverted; in the second, amnesic aphasia, the memory of words is lost or perverted. Aphasia includes not only aphemic and alexic affections in varying proportions, but dysmimic states, the several conditions of incoherency being often coexistent and owing sometimes to impaired memory, sometimes to faults of co-ordination, and at other times to both. These mental and motor difficulties have nothing to do with aphonia, where the inability to speak is owing to some laryngeal trouble impairing the vocal ligaments. Nor does the description include cases of mutism, or suppression of speech due to general alteration of the intelligence, such as the loss of speech observed in idiotism, cretinism, and deaf-mutism, or to a lesion of motion. Aphasia is a trouble bearing exclusively on the memory of conditions necessary to the expression of thought, and is limited to a group of symptoms most common to defects of expression not dependent on either paralysis, hysteria, or insanity. In aphonia the idea of language is unimpaired, and the organs of phonation only are implicated; in

aphasia there is an aplastic condition of the brain upon which the presence of tactile and visual ideas or auditory images fails to complete the conceptions of things that words represent; but the vocal organs are in a state of perfect integrity.

Loss or impairment of the power to express ideas by graphic representation is often associated with both amnesic and ataxic aphasia. In the amnesic form there is a noticeable inability of the will power in using words to express ideas. The volitional incitations that come from the brain in the production of articulate language are impaired in such a manner as to cause intercurrent suspensions of speech, hesitation, or confusion in talking; a misuse or forgetfulness of words; loss of memory of substantives and names; loss of memory of a foreign language or even the vernacular tongue, and terms may be persistently misapplied. The vocabulary becomes extremely limited; and the small number of remaining words the patient articulates in a staccato way, and they do not correspond to the thought. Among the earliest aberrations of speech in this affection are the substitution of obscene or profane epithets that are totally irrelevant to the objects to which they are applied. For instance, a lady in whom aphasia was first noticed, received company, and after greeting each guest formulated her politeness in the somewhat startling phrase, "Sit down, you dirty pig." Periphrastic forms of speech and the recurring or barrel-organ utterances, constituting what is known as *echolalia*, are also notable characteristics in some cases.

In ataxic aphasia the faculty of speech is entirely abolished or so impaired that only half articulations and automatic phrases of a few words are used. Names of things awaken no train of associations in the mind, and the phraseology may be reduced to a jangle of confused sounds, the utterance of oaths under emotional circumstances, and to a set word, sometimes accompanied by a nod of assent or of dissent, which in the amimic condition of some patients may signify just the opposite of what they intend. The impulse to add the force of emotion to the expression of ideas by profanity is one of the phenomena of aphasia. More curious is the ability in some cases to play chess, to calculate, to make music, both vocal and instrumental, to cheat at cards; and instances are known of the existence of a high degree of ataxic aphasia, along with the ability to manage business affairs with care and propriety. Strictly speaking, however, swearing is not a part of language, and the same may be said of the mental combination consummated without words, such as calculation, the playing of games, and music. The degree to which these faculties are impaired is a valuable diagnostic guide in estimating the state of the intelligence, and assists in the process of exclusion necessary to discriminate the amnesic from the ataxic form. In the former the aphasiac can write, and, when aided by suggestion, can remember forgotten words; in the latter variety he cannot write, nor can he utter an articulate expression after any amount of help or prompting.

Gesticulatory incoherence (*amimia*) may exist at the same time. In fact the mimic speech in this abnormal condition may become as impaired and as disordered as the other modes of language. In dysmimic incoherence there is wanting a harmony between the idea and the mimetic expression. The patient sometimes makes one gesture in the place of the other, and sometimes he expresses by this mode of language the contrary of his thoughts; at other times he forgets the gesture that expresses habitually a certain passion, and the strongest emotions fail to awaken a response.

Aphasia is of variable duration. It may be transient or permanent, lasting half an hour or a lifetime. We generally see it as the result of congestion, anæmia, hæmorrhage, rheumatism, syphilis, embolism, and the like. Perhaps ninety cases in a hundred are owing to congestion, to a hæmorrhage, or to a softening of the brain. An apoplectic or epileptic form of congestion opens the scene in most cases of aphasia, and of all the physical symptoms accompanying it right hemiplegia is the most common. This circumstance has caused the clinical division of the symptoms into two categories, according as they are exempt from paralysis or accompanied by right hemiplegia. Among other causes are diabetes, albuminuria, facial erysipelas, measles, scarlatina, typhoid fever, and migraine. Wounds of the head and of the encephalon, tumors, cancer, abscess, valvular lesion of the heart giving rise to embolism, organic disease of the brain, sunstroke, extreme cold, and snake-bites are further causes.* Independently of the grosser and visible lesions, aphasia may occur from nervous shock, or as a symptom of many nervous diseases, such as epilepsy, neuralgia, alcoholism, uræmia, or narcotic poisoning; from the toxic effects of lead or phosphorus, and from hephæstic hemiplegia or hammer-palsy. Hysteria and hysteroid affection and reflex action are mentioned in connection with the etiology of aphasia, but the tendency of thought among late writers is to ignore them as causes. Among the causes of great clinical importance are alterations in the medulla oblongata, the olivary bodies, and the lobe of the insula, which, by the way, is found in man and the simiidæ only, being slightly developed and devoid of convolutions in the latter. Any morbid processes in the brain, or any cause whatever that affects the formative processes or nervous impulse concerned in language, and interferes with the volitional incitations proceeding from the nerve-centres in the expression of language may give rise to aphasia.

Pathologists believe the most constant lesion of aphasia to be cerebral, and restricted to a certain portion of the brain. Necroscopic observations in cases of aphasia, with brain lesion following nervous affection or typhoid fever, show almost always softening of the brain, or generally an obliteration more or less complete of the middle cerebral artery with coexistence of valvular lesion of the heart, thereby establishing a constant relation in aphasia between cardiac affection, obliteration of the Sylvian artery, and cerebral softening. Less absolute than the foregoing are the attempts to determine the exact place of the brain lesion; and the question may be asked, Is there such a thing as a local centre of speech any more than a centre or seat for the soul? Phrenology, having assumed an inadequate generalization to bridge over the distance between mind and matter, has failed absolutely to define with precision the seat of the faculty of language, and the metaphysical divorcement of the mental faculties from each other and from their physical relations, if not obsolete, is obsolescent. Both phrenological and metaphysical notions are alike passing away, and a scientific basis may yet be established for the unity and indivisibility of mind. So varied and detailed are the faculties of the mind, that it is impossible to make of them a topographical distribution, even if we located many of the mental powers or attributes in various parts of the body wherever gray matter is found; and when we consider that the manifestation of language is no more a mental attribute than locomotion, for instance, and that it requires in its evolution the action of the whole series of anatomical possibilities—motor, sensory, and ideational—the subject becomes more obscure and complex. It is generally conceded, though, that the correct expression of ideas implies integrity of the cortical substance of the hemispheres. According to some observers, it is held that the disintegration of the brain substance in aphasia is caused by embolism of the left cerebral artery or its branches, an obstruction of which not only accounts for aberration of the function of expressing ideas by language, but for the frequency with which aphasia is associated with right hemiplegia, since the same artery also supplies blood to the corpus striatum of the same side. It is further held that the precise location of the lesion is in the posterior third of the third or inferior left frontal

* Observations of Dr. Ogle on the aphasia resulting from the bites of venomous snakes lead to the remark that the symptom is an early one that may last for an indefinite period when other symptoms have disappeared. He believes that the aphasia is owing to spasm in the middle cerebral arteries, and that when permanent it is occasioned by thrombosis of the arteries above the constriction. He further remarks, in regard to the poison acting preferably on a single artery or set of arteries, that this fact is consistent with the observed action of other poisons and drugs, notably with that of the cholera-poison, alcohol, quinia, digitalis, ergot of rye, belladonna, soda, and potash salts.

convolution. Other pathologists record cases that bear with almost as much effect on the negative side of the doctrine, which shows aphasia resulting from disease of the right hemisphere, and the absence of aphasia where the lesion was in the left speech-centre. The preponderance of evidence, however, goes to show that aphasia is connected with the disease of the left anterior lobe, a conclusion that seems beyond a questionable doubt.

It is also believed that there is a cerebral centre for many of the forms of thought and emotion that do not require words in their manifestation, such as the plastic arts, drawing and painting, music, the expression of joyous excitement, calculation, and writing.

Aphasics can often sing an exact tune without articulating the words, and a musician completely aphasic, being unable either to speak or write, has been known to write easily a phrase of music that he had heard sung. Aptitude to draw often remains; but in many instances artists have lost this. The ability to waltz, to calculate, and to cheat at cards with shrewdness sometimes remains. Generally, however, when the patient is affected both amnesically and ataxically he is not only unable to count his ten fingers, but is also unable to write. The speech-centre being presumably situated in the left hemisphere, it is also thought that the same half of the brain is the one in which exists the co-ordinating principle of writing, and the one from which proceeds the volitional incitation in the case of graphic representation of ideas. In the condition known as agraphia, that is, a loss, suspension, or impairment of the cerebral aptitude for writing, we have one of the most trustworthy means of taking an inventory of the patient's mental condition. The derangements of written speech are analogous to those of phonetic or articulate speech. In the two cases the harmony is impaired between the idea and its expression. Incoherency, whether verbal, written, or gesticulatory, is owing to the fact that the patient has forgotten the relation between ideas and the representative forms of their expression. Patients with ataxic agraphia may use their fingers tolerably well for other acts requiring delicate manipulation, such as sewing or drawing parallel lines, and at the same time be absolutely unable to write. Some patients make senseless scrawls or meaningless combinations of letters that printers would designate as "pi." Others are able to make their signatures only, to copy, or to write from dictation; but as a rule they write as badly as they speak, and those who do not speak are equally incapable of writing. In connection with this subject may be mentioned the phenomenon of "mirror-writing," in which the patient writes with the left hand and in a reversed way, forming the letters quite well, so that they are easily read when seen in a mirror. It is probable that Leonardo da Vinci was incapable of writing otherwise, as he is reported to have had right hemiplegia at the time he prepared a curious manuscript volume which is written in this reversed way.

In the matter of diagnosis the state of all the organs from the spinal cord to the tongue and lips should be studied, at the same time keeping in mind the diverse symptomatic details concerning the state of speech, intelligence, and writing, and the other various manifestations of thought that have been mentioned in the clinical picture of aphasia. The process of elimination should extend to all troubles of speech originating from the influence of moral causes, and those produced by hallucinations or delirious ideas, by nervous diseases, as catalepsy, epilepsy, ecstasy, etc., or the troubles depending upon incipient lesion of the intellectual faculties or upon alterations of the organs of phonation. These cases are not aphasia in the restricted and scientific sense in which it is proper to use the word. The same may be said of the suppression of speech that occurs in idiocy, cretinism, and dementia, where speech is suppressed in consequence of the absence of thought. It is the same with mutism consecutive on deafness in deaf-mutes and with mutism generally. A person is not necessarily an aphasic because he does not speak, nor should the morbid inability known as word-deafness and word-blindness be designated by the name of aphasia. Paralysis of the tongue (*glossoplegia* or *laloplegia*) in either of its two forms, masticatory or articular, may cause an error in the diagnosis of aphasia; so may the results of a lateral hemiopia, which usually occupies the right halves of both retinas. The dextral pre-eminence should always be taken into consideration. Most persons are left-brained and consequently right-handed. If left-handed they may become aphasic when the lesion includes the right hemisphere. In an ambidextrous boy aphasia has occurred from lesion of the left hemisphere.

The prognosis is almost always in relation with the lesion that produces the aphasic condition, and any forecast in regard to the patient's future must take into account the cause and location of the lesion. Aphasia consecutive on fever is of grave character, but where it is owing to the action of moral causes or nervous diseases, the disturbance is ordinarily temporary. Aphasia from traumatic lesions is more or less grave, according to the nature of the cerebral lesion originating it: as the lesion heals the aphasia disappears, consequently it can be said that the patient's chances for recovery in such cases are good. Not of such good augury, however, is the aphasia resulting from the bites of venomous snakes. The age of the patient is an important factor. Children have been known to recover rapidly after extensive cerebral destruction, while an incurable aphasia results in an old person from a small focus of disease. Cases depending on organic lesion of the brain are not only the most frequent of all, but the most grave. Where the aphasia is dependent on a slight congestion, a small cerebral hæmorrhage, or a primary affection of a curable nature, the patients often get well rapidly. A favorable result is not to be looked for in the cases accompanied by hemiplegia, which are generally rebellious and last for years without modification.

Aphasia sometimes gets well spontaneously in apparently severe attacks. In its treatment we are called on not so much to treat the impairment of speech as a distinct pathological entity, as to treat the diseased conditions that seem to be the cause of the aphasia. Having removed the cause, electricity should be applied to the tongue and other muscles of articulation, and a constant and systematic course of instruction, having for its object the redevelopment of the faculty of language and the exercise of the organs of phonation, should be persistently and judiciously enforced.

It is questionable whether the intellect is not injured in all cases of aphasia; but the extent of the injury it is not so easy to determine with the imperfect means of ascertaining which we have at our command. The frequent association of intellectual troubles in aphasia becomes apparent on recalling the morbid and habitual characteristics of the complaint, such as slowness and paresis of ideation, feebleness of memory and of attention, and the moral changes that show themselves by indifference and apathy. On one hand it is argued that the intelligence is preserved in all cases of aphasia, because a certain number of aphasics show by facial movements, gesture, and pantomime, or, in other words, by gesticulatory language, that they are still capable of understanding articulate language; on the other hand, alterations of the intelligence are advanced as the most prominent and distinctive characteristics of the aphasic condition.

In a general manner we can approximate to the mental state of aphasics by assimilating them in this relation to ordinary hemiplegics without trouble of speech. Both have the same pathognomonic causes, the same cerebral lesions that produce sometimes aphasia, sometimes hemiplegia, and sometimes the two symptoms together; and the same intellectual and moral modifications are observed in hemiplegia as in aphasia. When the imperfections of language persist from the outset without amendment, we must believe that they are dependent on a grave cerebral lesion, and consequently that there exists a profound intellectual trouble.

The mental disorders that are more or less constant in aphasics may be regarded from several points of view; according as the intelligence is slightly affected, manifestly altered, or totally abolished, as in dementia.

Alterations of language are generally accompanied by

such intellectual troubles as want of attention, loss of memory, incoherence, hallucinations, and delirious conceptions. Sometimes there is mental excitement, at others depression and enfeeblement of the intellectual faculties. Hallucinations of hearing and of sight are the most frequent in aphasia. A patient with aphasia has been known to have sitomania at the same time, and another in whom there existed marked anæsthesia believed his legs to be cut away. These false perceptions are particularly shown in the distrust of aphasics toward persons immediately surrounding them. The hallucinations are the same as those recognized in ordinary lunatics, and have for their origin the same lesions.

Among the forms of intellectual delirium most frequently observed in a partial form are the delirium of persecution, melancholy, and hypochondria. The instinctive impulses prompt a delirious propensity to steal, to drink, to commit suicide or homicide, to commit outrages against shame, and to attempt other acts that render one liable to sequestration in an insane asylum as feeble-minded.

The forms of maniacal excitement are much less common than those of depression, and present nothing in particular. They do not assume the varied aspects of the intellectual excitation observed in a great number of the vesanias. Depression is so much more common that it may be considered as constituting the rule in the aphasic condition. Its usual manifestation is in general intellectual apathy; indifference to friends, dress, and personal decency; by motiveless acts, egoistic tendencies, and irritability of character.

In some cases the aphasic may become a lunatic, and irresponsible for derelict acts that ought not to be referred to the courts. It then becomes necessary to take in advance precautions that hinder the patient from being hurtful to himself or his immediate surroundings; and the question arises as to whether the patient ought to be likened to an individual of sound mind considered responsible for his acts, and recognized as capable of being a legitimate party to a suit, or to other events of civil life. The different degrees of the intellectual trouble which is constant in patients of this class, are like those found in real dements. In a certain number of cases the patients cannot be considered as sane of mind in a medico-legal point of view; and the necessity for the intervention of the medical legist in the case of crime or misdemeanor committed by an aphasic does not admit of a doubt.

The means of judging of the intelligence are by the gesture, writing, speech, and the testimony of patients after their recovery; by the incoherence, whether verbal, written, or gesticulatory, with or without consciousness of the patient. Impairment of the gesticulatory speech, which may be as much disordered as other modes of language, is usually indicative of grave and complicated derangement of the numerous functions concerned in the evolution of thought; and loss or perversion of speech is always a concomitant of other cerebral affections. Of the temporary aphasics who have made analyses of their intellect the one most often quoted is Lordat, who, by the way, was a spiritualist of the worst kind before becoming aphasic, and gave other evidences of mental distraction. Besides, the history of his case shows that his mind was considerably injured after recovery. Doubtless many aphasics may read mentally when they are unable to do so phonetically; they may think without words; they may be speechless but not wordless, and they may have ideas without the necessary means to communicate them in any outward manner that admits of their being properly construed or interpreted; but everything goes to show that aphasia is a trouble essentially intellectual, and that the intelligence, considered in a general manner, sustains an injury more or less profound in all cases of true aphasia.

An estimate of the intellectual state, and consequently of the criminal responsibility of aphasics, is a problem of morbid psychology of the highest importance, and the physician's province and responsibility in criminal affairs where a question of this nature is mooted, ought to be as clearly defined as the other formalities of procedure. So confident is Legrand du Saulle of the injury to the intelligence in aphasia that he formulates his belief by saying that the intervention of the physician is claimed in all cases of accusation directed against aphasic persons.

Not less complex than that of criminal responsibility is the question of civil capacity in aphasia. Serious problems like the following are likely to occur any day: Is aphasia a sufficient reason for the privation of the exercise of civil rights? Is it a valid reason for opposition to a marriage or to a plea in abatement? May it be considered as a hindrance to the usage of the right to make one's will?

There are two cases in which wills may be attacked: when the capacity of the testator is put in doubt, or when the testamentary act is not regular.

The validity of wills made or signed by aphasics has been frequently tested before the courts. Aphasia may exist with perfect testamentary capacity in some cases; in others the patient may not be competent to make a will, or he may not himself make the will but be unduly influenced by the suggestion of others regarding the contents of the will. A will case is mentioned in which there was complete aphasia and agraphia, but the patient could turn to a dictionary and point out words. Generally speaking, where there is no emotional change of character and disposition that would directly influence the opinion which the testator holds of his relatives, he should be considered to possess perfect testamentary capacity. But in the present state of our knowledge of the subject it seems almost impossible to formulate clear and explicit rules for guidance on this point. It is to be wished, however, that with the advance of science we may some day be able to analyze and to point out with more precision the exact nature of the lesion causing the suppression of the natural relations that exist between thought and its representative signs. *Irving C. Rosse.*

[1] Sext. Philosoph. Pyrrhon, Hypotypos., lib. I., c. xx., edited by J. A. Fabricius. Leipzig, 1718, in fol.

APHRODISIACS. Remedies which increase the sexual appetite or restore the power of erection. The principal agents employed for this purpose are alcohol and other stimulants, cantharides, damiana, ergot, ginger and the spices, iron and other tonics, phosphorus, and strychnia. A diet consisting largely of animal food, and the wearing of warm clothing, especially about the loins, are valuable adjuncts to increase the effects of internal remedies. The sexual powers are often weakened or destroyed by prolonged and steady mental or physical labor, and rest is therefore indicated in such cases. When, as is frequently the case, weakness of the genital functions is only part of a general debility, tonics should be exhibited and the diet should be stimulating and composed largely of meat. When these measures are ineffectual, recourse must be had to the direct aphrodisiacs. Strychnia and phosphorus are the best remedies of this class, for cantharides is very uncertain in its action, and sometimes fails entirely. Damiana enjoyed a great popular reputation at one time, and is still employed to a considerable extent as a sexual stimulant. Ergot has been found of service in cases of impotence due to insufficient erectile power. *T. L. S.*

APHTHÆ. (Syn.: Thrush, Sprue; Fr., *Aphthes, Muguet;* Ger., *Mundschwamm, Fasch.*) These various terms are by most writers indifferently employed to designate two affections of the mouth, which, though resembling each other in their gross appearances, are really separate and distinct conditions. The one is a simple form of ulcerative stomatitis, the other is a specific inflammation excited by the presence and growth of a special fungus. In the simple non-specific sprue there first appear numerous small transparent vesicles, filled with a clear fluid, and surrounded by a reddened slightly inflamed areola. The vesicles may occur as isolated points, or may be grouped together or even confluent. They are usually seen first upon the tongue, and spread thence to the neighboring parts of the mouth and fauces. The vesicles soon become cloudy, lose their fluid contents, and then present themselves as slightly elevated whitish spots on

the lingual and buccal mucous membrane. These patches are easily detached, and when removed may leave shallow ulcerations covered with a thin film of dirty yellow slough. The eruption is usually attended with malaise and a moderate degree of fever. The disease occurs mostly in sickly infants suffering from digestive disturbances, but may also attack adults who are debilitated by disease or old age. There is no special treatment for this affection. Attention should be directed chiefly to the correction of the gastric disorders upon which thrush depends. A small saline aperient may be given first, and may then be followed by alkalies to correct the acid condition of the primæ viæ. But the fault will generally be found to lie in the infant's diet; either the child is being nursed with the bottle, or it is being fed with pap which it is unable to digest. If the infant is nursing and the mother is not able to supply it with the necessary sustenance, a wet-nurse should be procured. An older child should be fed chiefly with milk, to which a sufficient amount of lime-water has been added, and with small quantities of finely cut mutton or beef. Vegetables and starchy food are to be temporarily eschewed. In the aged, tonics and stimulants are called for, attention being especially directed to the primary affection. The inflamed parts of the mucous membrane may be repeatedly touched with a camel's-hair pencil dipped in a solution of borax in glycerine. But frequent washing out of the mouth should be avoided, and force should never be employed to remove the patches. The constant swabbing out of the infant's mouth is perhaps one of the most frequent causes of stomatitis in the new-born.

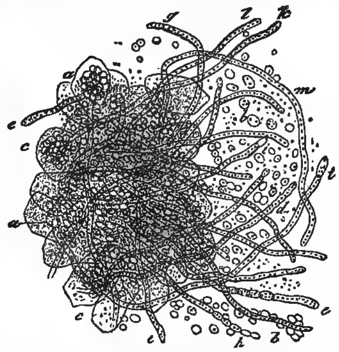


FIG. 226.—A Patch of Aphthæ, magnified 360 diameters. *Oïdium albicans.* (From Robin.) *a, a,* Cells of epithelium; *b, b,* spores, isolated or united in the form of chains, or arranged in round or irregularly shaped groups, adhering to the surface of the epithelial scales; *d,* cylindrical tubular filaments, containing in their interior molecular granules, *e, e,* swollen extremities of the tubules; *g,* ovoidal swellings; *h,* ovoidal cells, articulating with each other; *i,* terminal ovoidal cell.

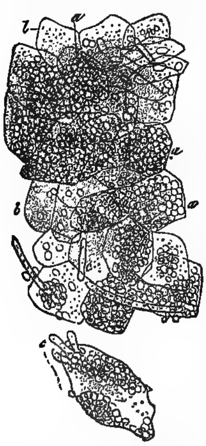


FIG. 227.—Another Portion of the same Patch, the Filaments are seen in the Process of Development from the Spores, etc. (From Robin.) The spores are seen in round groups (*a, a*), or in patches of the same shape as the epithelial scales (*b, b*); tubes (*c, c*) may also be seen developing from these groups or from isolated spores.

The specific form of aphthæ presents nearly the same clinical features as that just described. When it occurs in a previously healthy child, there are usually a few days of malaise preceding the appearance of the stomatitis. The mouth may at this time be hot and tender, so that the infant may show a reluctance to take the breast or the bottle as the case may be. Soon small whitish spots appear about the tip of the tongue, and spread thence to its sides and to the other portions of the mucous membrane of the mouth and pharynx. The patches are white or slightly yellowish in color, a little raised above the surface and somewhat cone-shaped, looking very much like little collections of curdled milk. They are at first closely adherent to the mucous membrane, but later are easily detached, leaving a smooth glistening surface upon which a new patch is quickly reformed. If any force has been used to remove the spots excoriations are formed. These ulcers are rounded or oval in shape, with clean-cut, not elevated, edges, their surface is of a dirty yellow color, and they are surrounded with an inflamed areola. These whitish curd-like patches consist of epithelial cells and the spores and filaments of a fungus plant known as the *oïdium albicans.* The parasitic nature of the affection was discovered simultaneously by Berg, of Stockholm, and Gruby, of Vienna, working independently of each other. This fungus consists of filaments and spores, the latter lying upon and between the imbricated cells of the epithelium, while the former penetrate the cells and frequently pass even into the submucous tissue. The filaments are simple or ramified, often containing within them elongated cellules, and are usually tangled together, and interwoven into a network containing spores, epithelial cells, and granular matters within its meshes. Fig. 226 represents a fragment of one of these curd-like patches. Fig. 227 represents another portion of the same patch, showing the growth of the filaments from the spores. Fig. 228 shows the mode of growth of the filaments from the spores, the manner of their ramification, and the ovoid cells contained within the fully developed tubules.

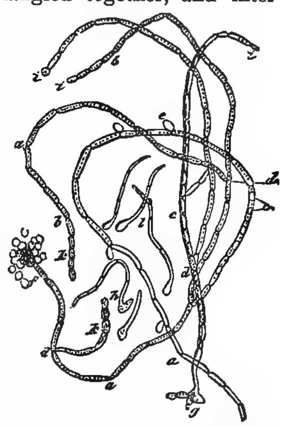


FIG. 228.—Fully Developed Filaments of the *Oïdium albicans.* (From Robin.) *a, a,* Points of constriction; *c, c,* ovoid cells contained within the lumen of the tubules; *d, d,* ramifications of tubes; *e,* a new branch formed by a single cell which is becoming elongated to form a filament; *g,* mother spore sending out an offshoot; *h,* germinating spores; *l,* development of filaments from isolated spores.

Muguet is not in itself a grave affection, but is often of significance as indicating some serious disturbance of the digestive apparatus. It occurs in weakly children, insufficiently or improperly fed, or living in damp and unhealthy surroundings. The diagnosis seldom presents any difficulty, diphtheria being the only affection with which it is at all likely to be confounded. The eruption of sprue is usually limited to the anterior portions of the buccal cavity, or is at least more plentiful in this locality, while in diphtheria these parts are only secondarily, if at all, invaded. The treatment is the same as that of the non-parasitic form. No attempt should be made to remove the patches beyond what may be accomplished in this way by a soft brush. Borax may be used very freely. Sulphite of soda in solution has been recommended. If the curd-like patches are constantly reproduced, the ulcerated surfaces from which they arise may be touched lightly with nitrate of silver in solid form or in strong solution. The treatment of the local affection, however, will usually present but little difficulty if the primary disorder of the digestive tract be corrected.

Thomas L. Stedman.

APOLLINARIS, an acidulated water of Rhenish Prussia, mostly bottled for export. It is possessed of no medicinal value, being simply an agreeable table-water.

H. F.

APOPLEXY (ἀπό, from, and πλῆξις, a striking). The word apoplexy means literally a knocking down or stunning, a stupefaction. It is equally held to mean a palsy of the body or some part of the body, or of the mind, in consequence of a sudden hæmorrhage, causing functional deficiency of the brain without the suspension of respiration and circulation. The same condition, as regards nervous phenomena, exists in syncope and asphyxia, but the first of these begins in the heart and the second in the lungs.

Formerly every disease accompanied by sudden abolition of consciousness and power of motion, followed by a certain degree of paralysis, was called apoplexy. The term was also applied to almost all cases of sudden death,

notably to those owing to the rupture of an aneurism, and to the comatose state occurring in certain diseases. The word having been used generically to denote an epitome of the symptoms, and being applied to diseases widely different, ought to be struck from the nosological list.

Heretofore different kinds were distinguished: *Sanguineous* apoplexy, the consequence of a sudden extravasation of blood occurring in connection with an organic disturbance of the brain, such as hæmorrhage or obstruction of its blood-vessels; *serous* or pituitary apoplexy, occasioned by a serous effusion into the arachnoid or in the cerebral ventricles; and *nervous* apoplexy, in which no textural change could be discovered. Apoplexy of the new-born is a term applied to that state of apparent death in which a child at birth, after difficult and prolonged parturition, has impeded circulation, from any cause whatever, that occasions a stasis in the cerebral vessels. A better name for the condition is asphyxia. The present tendency of thought on the subject is to use the word apoplexy for the hæmorrhagic form only, while the term serous apoplexy is used to denote an acute cerebral congestion, and the term nervous apoplexy to denote an acute brain anæmia. Some writers deny the existence of the latter form, which is nothing more nor less than syncope, and the so-called serous form is extremely rare. Indeed, it is doubtful whether more than one form, which limits the condition to hæmorrhage into the brain, can with propriety be admitted.

The effusion of blood into other parts of the body, with sudden functional disturbance of the same, has caused observers to see in them an analogy to hæmorrhagic brain apoplexy, and thus we have the conditions known as spinal apoplexy or hemato-myelitis, pulmonary apoplexy, retinal apoplexy, placental apoplexy, and the like, the name of the affected organ supplying the specific designation.

In cerebral apoplexy death is often of sudden occurrence, the immediate cause being effusion of blood into the brain substance, the ventricles, the meninges, or the cerebellum. The name apoplexy will be limited to the discussion of that form that is best known, the most common, and the most formidable, namely, that characterized anatomically by encephalic hæmorrhage.

Allied to apoplexy are coma or stupor, arising from various causes affecting the brain, such as pressure, and the apoplectic states brought about by poisoning, drunkenness, uræmia, etc., a knowledge of which is useful from a judicial point of view.

See Cerebral Hæmorrhage; also Hemiplegia, Alcoholism, Poisons, and Uræmia.

Irving C. Rosse.

APOTHECARY. This term is derived from the Greek Ἀποθήκη, and strictly means a repository, without regard to the character of the articles placed in it. It was used, however, by Galen for the receptacle where he kept his medicines. In modern usage it varies somewhat in meaning. In England it indicates a general practitioner who supplies drugs to his patients. In Scotland it is used of persons who compound and sell drugs, but recently this class is more strictly described as pharmaceutical chemists, or chemists and druggists.

In France, where the Code Napoleon is the basis of law, the term has a different meaning from druggist, the latter being used only of those who sell drugs at wholesale or in the original packages, while an apothecary is a person who compounds and sells drugs for private and individual use. There is a decision, under the modern Roman Code, to the effect that a druggist has no right to *pulverize* and sell chinchona bark, this being considered "compounding," and hence belonging alone to the apothecary. In this country the same distinction has prevailed to some extent, but now in general usage apothecary is synonymous with druggist. One of the States (Louisiana) has by a judicial decision declared that the distinction between an apothecary and a druggist still exists; while in another (Massachusetts) it has been held that a person may be an apothecary who does not compound medicines. In England apothecaries seem originally to have been irregular practitioners of medicine. They did not belong to the corporation of physicians, which was established in London in 1518, nor to the barber-surgeons, who were similarly incorporated in 1540.

In 1543 an Act of Parliament was passed recognizing and protecting these irregular practitioners, who, from the fact that in most instances they kept shops for the sale of medicines, were called "apothecaries." They were incorporated with the grocers into one of the city companies of London, in 1606, and were made a separate company in 1617. During the seventeenth century a dispute sprang up between the physicians and the apothecaries, as to the extent of the rights of the latter. It was contended, on the part of the physicians, that the apothecaries should confine themselves to the dispensing of medicines, while the latter claimed the right to prescribe also.

This question was taken into the courts, and was finally decided by the House of Lords in 1703, when it was held that the apothecaries had the right to prescribe and administer medicine as well as to compound remedies. In 1715 an act was passed, giving the Apothecaries' Company the right in London to destroy drugs unfit to be used.

In 1748, ten examiners were appointed without whose license no one could dispense medicines in London and for a distance of seven miles around. In 1815 the Apothecaries' Society was granted the right to issue licenses to apothecaries in England and Wales. In 1860 this privilege was extended to the whole of Great Britain.

Until 1815 the education of medical practitioners, including apothecaries, was optional in England and Wales, although many members of these professions were graduates of the universities; but the act requiring the issue of licenses soon brought medical schools into existence. It was found, however, that notwithstanding the requirements for medical knowledge, many applicants were deficient in preliminary education, and in 1860 an act was passed requiring an examination in the Arts before obtaining a license.

In this country the various States have laws prescribing the conditions upon which persons may have the right to compound and dispense medicines, and these laws in general require some preliminary education, together with a diploma from a school of pharmacy, or an apprenticeship in a drug establishment. These laws differ in the several States, and extended reference cannot be made to them. There has grown up a distinction, on account of the wonderful growth of the pharmacopœia and the increasing demand for drugs, between manufacturing and dispensing pharmaceutists or apothecaries. The former manufacture and deal only at wholesale, or in comparatively large quantities, and the latter compound and dispense medicines and drugs to the individual purchaser.

The liability of apothecaries or druggists for negligence in the preparation or sale of drugs arises from common law principles, and need not be created by positive statutory enactment. Most of the States have, however, carefully drawn laws punishing neglect on the part of the apothecary.

Without statutory legislation the vendor of drugs is upon the same legal footing as the seller of provisions, and is held to warrant their good quality.

The motto of *caveat emptor* is held not to apply to bad or unwholesome provisions, and the same exception applies, with much stronger force, to drugs, the quality of which can rarely be tested by the purchaser. The motto enforced by the courts in these cases is *caveat venditor*. Any adulteration of drugs is punished severely in all cases, and the statutes on this subject are referred to under the title of Food and Drug Adulteration.

Aside from the statutory declarations concerning the liability of apothecaries and druggists, it may be remarked, that in the cases where the apothecary prescribes as well as compounds the medicine, the liability is similar to that of the physician, and the latter is held responsible for reasonable skill and knowledge in the practice of his profession. This liability is in addition to that which adheres to the special function of the apothecary, the compounding of medicines. The apothecary is held to warrant the good quality of his preparations, and to be absolutely

free from negligence, because the only protection of the public lies in his strict accountability.

The legal rules applicable to apothecaries as well as to physicians are stated more at length under the title of Malpractice, but some general principles may be given here. As has been already said, there is an implied warranty that the drugs sold are of good quality. This warranty, in the case of articles which deteriorate by the lapse of time, applies only to the time when they pass out of the vendor's hands. The apothecary is not held, however, to an absolute guarantee under all circumstances. If, for instance, there should be, without his knowledge, a wilful substitution by another of poison in a jar containing a harmless drug, both being similar in appearance, and the poison should be sold in place of the drug, the apothecary would not be liable. Negligence must be shown before a conviction is possible. The liability of the original vendor for his own negligence continues, notwithstanding the fact that there may be a number of intermediate vendors between him and the consumer. In a well-known case, a jar labelled by the manufacturer as extract of dandelion contained really extract of belladonna, and there were several changes of ownership without knowledge of the substitution before the drug reached the retail dealer, who sold it for extract of dandelion, to the great injury of his patient.

Here the last vendor was held to be free from negligence and the manufacturer was punished severely.

The mistake of supplying a harmful drug for an innocent one may be punished either criminally or civilly. The person guilty of the mistake, in case death ensues, is liable to a charge of manslaughter, whether the mistake is made wilfully or negligently. If a physician carelessly orders an injurious drug in a prescription, the apothecary is not freed from responsibility because he carefully and literally follows the directions given. He is expected to have sufficient knowledge to detect the mistake, and if he does not, is held liable equally with the physician.

There are special laws in the various States carefully regulating the sale of poisons, and the bottles or packages are required to be labelled as poisons, and marked in addition with the name of the special drug. If this is not done the offender is liable to the penalty of the statute, but is not responsible to the person injured if the character of the drug is fully made known to him, and he is cautioned against its use.

Statutes forbidding the sale of spirituous liquors are generally held not to apply to druggists, who use them in compounding medicines, and liquors are usually allowed to be sold for strictly medicinal purposes.

Henry A. Riley.

APPETITE—the desire to take solid or liquid food, which is accompanied by a painful sensation and urgent desire in the condition known as hunger. Hunger marks simply the desire to eat; appetite, the pleasure that we find in eating; when we are pressed with hunger we eat with appetite.

The desire of a thing for the satisfaction of the senses is generally used in the plural, thus we speak of sensual, carnal, or depraved appetites. In the singular and absolutely, the word appetite is a specific term that modern psychology has differenced from the generic word passions. It calls appetites the passions that correspond to the wants of the animal nature.

Taken in a particular sense, the word appetite denotes a want to eat, and differs from the want of liquid aliment, causing the peculiar sensation known as thirst. Figurative references to appetite, and the occurrence of the word in a great number of locutions and proverbs, are well known. Shakespeare's good digestion that waits on appetite; the Galenical admonition always to get up from the table a little hungry; the Gargantuan saying of Rabelais that appetite comes by eating, and that certain sweetness of forbidden things that even Solomon says is pleasant, are formulas familiar to most every one. Not so well known, however, are the epithets applied to appetite in a scholastic sense, which speak of the faculty by which the soul inclines toward good as the concupiscible appetite, and the rejection or avoidance of evil, the irascible appetite.

The venereal appetite, for obvious reasons, does not need to be defined.

With the other propensities to satisfy desires or to flatter the senses, it must be excluded, as we shall apply the term appetite to the desire for food and drink only.

This organic sense is manifested in its hybrid characters by periodic languor of the stomach and slight fatigue—sensations that evidently have their departure in the entire system. In fact, life itself is an affair of appetite, and nothing is more real in a practical point of view. The study of its diverse modes of existence offers to the practitioner not only a source of interest, but a subject that may be of diagnostic import, and may furnish a therapeutic indication. It is hardly necessary to pass in review the numerous theories that have been advanced to explain the sensation of hunger.

Normal or physiological appetite indicates by agreeable sensations the necessity to furnish alimentary material to repair the losses of the economy; exaggerated or abnornal appetite is a nutritive state indicating a more desperate situation, that may range all the way from simple appetite in convalescence up to voracity and other pathological exaggerations.

Appetite may be modified in various ways. Circumstances favoring it are youth, muscular or intellectual exercise, contentment, regular habits, a bracing atmosphere, sufficient and regular intervals between meals, and simplicity of diet. It is said that people of most vitality bear hunger badly. The histories of many shipwrecks and disasters at sea show that delicate women have survived the effects of thirst and famine when strong men have died. The writer has also noticed, during two Arctic expeditions which he accompanied in search of the exploring yacht Jeannette, that the strongest men of the party stood the deprivation of food the worst. The effect of cold in increasing the appetite is a matter of common experience. Any vigorous man in the prime of life, who has been shooting all day in a sharp, crisp atmosphere, will be surprised at his gastronomic capabilities. It may be remarked here, however, that some acquaintance with the subject warrants the assertion that Eskimos have not the enormous appetites with which they are usually accredited, and that the popular notion regarding their edacity is one of the current fallacies. Instead of being great gluttons they are, on the contrary, moderate eaters. The Eskimo who accompanied Lieutenant May, of the Nares Expedition, on his sledge journey, is reported to have been a small eater, and several Eskimos employed by the writer's party as dog-drivers and interpreters were, as a rule, smaller eaters than our own men. It is, perhaps, the revolting character of Eskimo diet—rancid oil, a tray of hot seal entrails, a bowl of coagulated blood, or partly hatched eggs, for example—that has caused an overestimation of the quantity actually eaten. Persons in whom nausea and disgust are awakened at tripe, putrid game, or mouldy and maggoty cheese, affected by so-called epicures, not to mention the bad oysters preferred by George I. to fresh ones, would doubtless be prejudiced and incorrect observers as to the quantity of food an Eskimo might consume. Moreover, the reported cases were probably exceptional ones, happening in subjects who had been living out-of-doors on little else than frozen air for perhaps a week; and the narrators are entitled to further allowance when we consider that ethnology is a new science, and veracity a virtue that is quite young among travellers.

Such causes as intemperance, sedentary life, absence of exercise, emotional conditions, and the like, are detrimental to appetite. Another cause that is said to "cloy the hungry edge of appetite," is love, when it is condemned to abstinence. Doubtless many have lost appetite from this cause; but it is harder to divine how the writers of amorous verses, who declare that they "live on love and feed on kisses," derive nourishment from such dainty morsels.

Appetite varies at the different periods of increase, maturity, and decline. The infant's first squall is for

food; he soon eats himself into boyhood, when, it has been truly remarked, the pantry becomes his place of devotion, and the butcher and baker his tutelary saints. At vigorous maturity the holy fire of the cooking range, the artist-like management of the palate, and the triumphs of the kitchen, are still objects of devotion and interest. Declining into "the lean and slippered pantaloon," the unpoetical fact still remains that dinners are necessary at this time of life, in which the appetite is oftener one of desire than want; and for this reason it is said that old men bear fasting better than the young.

In convalescence the appetite may be weakened, exaggerated, or perverted from the normal standard. The fathers of medicine have left but little for their successors to do in the matter of dietetics, and nothing fundamental has been said upon the question of appetite in convalescence since the days of the Aphorisms.

Simple defect of appetite is known as anorexia; its pathological exaggeration as boulimia, also *fames canina*, polyphagia, and lycorexia. Anorexia is found immediately after great loss of blood, also in anæmia, tubercular meningitis, and in almost all conditions where the glandular structure of the stomach is impaired. In chronic ulcer, however, the appetite remains good. More remarkable is the fact, that in simple basilar meningitis, patients sometimes eat well. Boulimia occurs in convalescence and in epileptics, in hysteria, mania, gastralgia, chlorosis, diabetes insipidus, and intestinal worms. Subjects of boulimia have been known to devour incredible quantities of food, such as twelve pounds of bread in twenty-four hours, and in six days three hundred and seventy-nine pounds of food. Boulimia is sometimes congenital. Perversion or depravity of the appetite, either congenital or acquired, is noticed in a special neurosis of the stomach called malacia, when the patients long for substances unused as food, but containing, however, nutritive principles, and pica, when they eat and covet objects that are not assimilable. Perversions of the appetite are most common among the insane, but are not confined exclusively to them. Most physicians have seen children, chlorotic girls, or women in the early months of pregnancy, who eat with apparent relish such objects as chalk, pickles, slate-pencils, coal, plaster, ashes, earth, and the like. A small child has been known to indulge its lithovorous propensity so far as to eat one hundred and fifty pebbles, some of them the size of a walnut; a young woman in a year and a half consumed more than eighty pounds of rotten-stone; an habitual smoker constantly ate his pipe while smoking, and another person was known to eat whip-handles. Instances are recorded of men swallowing such objects as wine-glasses, billiard-balls, knives, watches, etc., but in these instances the act was not owing to any prompting of appetite, but to a desire to appear reckless and daring. In women this gastric depravity results either from vanity or uterine causes. Such fantastic crudities as chalk, vinegar, brine, and other edible curiosities too disgusting to mention, have been taken to answer the purposes of silly conceit and the promptings of mistaken vanity. In extreme cases the depravity extends to numerous vile objects, liquid as well as solid. Nothing is too strange or too dirty to encounter. In allotriophagy patients have been known to eat hair, dirty rags, insects, and rats; in polyphagia astonishing instances of edacity are related, such as that of a man having taken the incredible quantity of forty kilogrammes of food in a day, or that of another who was in the daily habit of eating enough food to keep ten men. Lunatics have been known to make small junk-shops of their stomachs. A *post-mortem* examination of the stomach of an unfortunate lunatic has revealed nearly twelve pounds of miscellaneous articles, such as nails, buttons, coins, steel buckles, a shoemaker's awl, and the like. The state of mind that takes pleasure in eating such articles leads to the remark that, as equilibrium of mind is in a great degree dependent on digestion, so the converse is true, that the appetite is, more than we are aware of, dependent on the condition of the brain.

Among the more remarkable of these perversions is the condition often existing among negroes in intertropical countries, known as geophagia, cachexia Africana, or, in plain English, dirt-eating. Veracity in the matter of voyages and narratives being a virtue of recent acquirement, the writer would feel disposed to regard as fabulous most of the recorded instances related by travellers and missionaries, had he not personally witnessed geophagia in negroes. According to Humboldt, South American crocodiles swallow stones and bits of wood during the dry season. The same has been observed in the Egyptian crocodiles, and stones have been found by Cuvier and Owen in the stomachs of crocodiles that have died in zoological gardens.

On a late visit to the Fur-Seal Islands of Alaska, the writer learned that both the fur-seals and sea-lions frequenting these islands during the storge period are in the habit of swallowing large quantities of water-worn pebbles and boulders. Mr. Henry W. Elliott, of the Smithsonian, who has investigated the subject quite thoroughly, says that the lithovorous habit is limited to the adult males and females. He has examined the stomachs of hundreds of these animals that were driven up and killed immediately after their arrival in the spring, and in the empty stomachs of many of the "old bulls" were found stones weighing half a pound apiece. One paunch contained in the aggregate over five pounds of large pebbles, and in the stomach of one sea-lion there were more than ten pounds of stone, some of them of great size. According to old sailors, these animals swallow stones for ballast; but the ballast theory is untenable. Mr. Elliott, in his "Monograph of the Seal-Islands of Alaska," ascribes as a cause for this habit the presence of nematoid worms, which he found in nearly every instance in the hundreds of stomachs examined. Among the thousands of disembowelled Pribylof fur-seal carcasses there were noticed no abnormal or diseased viscera, and in no single case has anything ever been found other than the bile or ordinary secretions of this class, with the marked exception of a small cluster of worms from the size of a walnut to a bunch the size of a man's fist. The long fasting that these animals undergo during the rutting season may be an additional cause for swallowing stones, which by their bulkiness aids to relieve the sensation of hunger during that period. How the intense physical energy of these animals is maintained during an abstinence from food of any kind, or from even water, during three and four months, is simply wonderful. It is evidently sustained, Mr. Elliott thinks, by the absorption of their own fat, with which they are so liberally supplied when they first come out of the sea and take up their positions on the breeding-grounds. This remarkable endurance and abstinence reduce the animal to a mere bony shadow at the end of the season, when he crawls laboriously back to the sea, abject and spiritless, to renew a fresh lease of life; and it is related that the violation of supposed physiological laws does not appear to affect them, for they come back just as sleek, fat, and ambitious as ever, in the following season. The Orinoco natives accompanying Humboldt on an expedition were in the habit of eating a pound and a half of earth daily, and enjoyed vigorous health for two months of the year on no other apparent subsistence than masses of silicate of alumina and lime. Goldberry states that he has eaten the earth affected by the geophagist without disgust or subsequent inconvenience, and two Alpine travellers relate that on one occasion each ate about five ounces of talc without inconvenience, and found that it allayed the sensation of hunger. Another traveller has seen the appetite so vitiated among children that it was necessary to tie them up to prevent geophagy. Many persons have seen in a museum the tin masks worn by West Indian slaves for the same purpose. It has been observed at Banco, on the Madelina River, that women occupied in making pottery swallow from time to time little balls of the earth that they are moulding. Geophagy is also common among the natives of Guinea and of New Caledonia. At Popyan and other places in Peru earth is sold as a comestible. It is made into cakes and patties by the women of Java, who eat it during pregnancy. The habit is also known to exist among the wandering Tunguses of Siberia, the negroes of Senegal, and the aborigines of the Idolos Islands. Nor is it

the exclusive infirmity of degraded and primitive tribes. The elegant señoras of some provinces of Spain and Portugal are said by a French writer to nibble with delight the earth of Bacaros, when it has served in the confection of vases in which wine has remained a certain time, and has left some little of its aroma. According to Dr. Joseph Pitt, geophagy prevails epidemically among the poor white people as well as the negroes in North Carolina, along the borders of the Roanoke River (*N. Y. Med. Repos.*, 2d Hexade, vol. v., p. 340). Dr. John Le Conte, of Savannah, Ga., says he has frequently observed the same habit among the poorer classes of whites inhabiting the pine barrens and thinly settled portions of Georgia (*So. Med. and Surg. Jour.*, August, 1845, p. 431). We learn from the same authority that this gastric depravity is not confined to human beings; for in Georgia, on the north side of the Altamaha River, in McIntosh County, cows feeding on coarse grass, probably deficient in the phosphatic or calcareous ingredients essential to healthy nutrition, are constantly observed to chew *bones*. Pica has also been noticed as a symptom in horned cattle and in sheep in Gascony, supposed to be owing to the deleterious influences of what are termed *landes alliotiques*. The writer has witnessed coprophagy in one of the elephants confined in the London Zoological Gardens.

There are reasons for believing that geophagy is hereditary and the entailment of a habit contracted in Africa. Humboldt thinks it a habit prolonged from generation to generation. Concluding from analogy, the habit of dirt-eating is no less disgusting at first than that most loathsome of indulgences, chewing tobacco. In many instances geophagy is an uncontrollable habit; in others it is the outcome of inexorable want, and is resorted to for the purpose of appeasing hunger and to give bulkiness to a meagre supply of organic food. Owing to the fact that a spider may be confined in a box for ten weeks, and supposed to be capable of obtaining nutriment from devouring zinc sulphate, and that certain coleoptera derive sufficient material from earthy matter for nutriment, growth, and metamorphosis, it has been suggested that the smooth, unctuous, aluminous clay in which the dirt-eater delights may supply a deficiency in some of the ingredients of his ordinary food. There are, however, so many opposing facts connected with insect life that offset the foregoing, that this entymological analogy, to say the least, furnishes but a poor base of induction.

The tendency among medical men is to regard the geophagic propensity as a vitiated state of the appetite resulting from a neurosis of the function of digestion. It may be the outcome of habit in some instances; in others it is caused by bad and insufficient diet, chloro-anæmia, inflammation of the mesentery, and the presence in the duodenum of numerous nematoid parasites known as ankylostomes.

The subjects of geophagia are emaciated, they have a protuberant abdomen and sallow complexion. There is a tendency to serous effusions, and hypertrophied liver and spleen are usual concomitants. The condition may be confounded with paludial cachexia or beriberi of a hydropic form.

Therapeutic indications in geophagy naturally point to removal of the cause and the substitution of proper diet. Dr. Franklin, with his usual character and wisdom, having recommended a daily allowance of spirits, it has been tried with success.

Other pathological states of the appetite occur in the condition known as lycanthropy, and in necrophagy depending on mental degradation, superstition, or dementia. An intense dread of food (Sitophobia), or an obstinate rejection of food (Sitomania), is often found among the insane. Instances are reported on undoubted authority, of insane patients having fasted forty, fifty, and even sixty days, and recorded cases of coprophagy and skatophagy abound in the annals of psychiatry. *Irving C. Rosse.*

AQUAMALARIAL FEVER. This term was suggested by Dr. Smart, U.S.A. (*Am. Jour. of the Med. Sciences*, January, 1878), not as indicating a variety in the clinical aspects of malarial disease, but to draw attention to the importance of the theory of the transmission of the disease-poison by means of the water-supply. For a presentation of the facts and arguments on which the theory is based, see Water, Sanitary Aspects of.

ARBOR VITÆ (*Thuja*, U. S. Ph.; the fresh tops of *Thuja occidentalis*, Linn.; Order *Coniferæ*). This is a North American tree, growing abundantly in Canada and the Northern States, and extending at higher elevations as far south as Pennsylvania and Virginia. It is a middling or good-sized tree with spreading and graceful branches, and a fine, often large, trunk, which supplies a close-grained, durable wood. It is occasionally planted here for ornament, but more often abroad, where it is valued as a garden tree; the *Arbor vitæ* of our gardens is usually the smaller, closer, erect-branching *Thuja orientalis* Linn., of Asia, which is a favorite hedge-plant. The genus to which these belong is a small one of only a dozen species (only two or three in its narrowest limits); its nearest affinities are with the Cypresses, from which it is distinguished by longer cones and fewer (2) ovules under each scale, and with the Junipers, which differ in having berrylike fruits.

The twigs are thus described in the Pharmacopœia: "Twigs flattish, two edged, the scale-like leaves appressed and closely imbricate in four rows, rhombic-ovate, obtusely pointed, with a roundish gland upon the back; of a balsamic, somewhat terebinthinate odor, and a pungently aromatic, camphoraceous, and bitter taste."

Arbor Vitæ contains about one per cent. of a *volatile oil*, something like that of Juniper; *tannic acid* (Pinitanic); a minute amount of a glucoside called *Thujin*, etc.

MEDICAL PROPERTIES.—Astringent, diuretic, expectorant, tonic, etc., in no direction of much value. Sometimes used for cough; a tincture is employed occasionally for external use upon ulcers, rheumatic joints, etc. Dose, two to four grams. There is no officinal preparation, but an alcoholic Fluid Extract would be a suitable one.

ALLIED PLANTS.—For Ord. *Coniferæ*, see TURPENTINE.

ALLIED DRUGS.—See ARNICA and HAMAMELIS in external use; see also JUNIPER. *W. P. Bolles.*

ARCACHON. The town of Arcachon lies about thirty miles southwest of Bordeaux, on the margin of a very extensive salt-water lake, and some ten miles back from the Atlantic coast. The modern origin of the town is indicated by the motto inscribed upon its coat-of-arms, *Heri solitudo, hodie pagus, cras civitas;* which motto is also an indication of the former character of the surrounding country. A desert waste of barren sand-dunes extended for many miles in every direction about the present site of Arcachon, until the French government, some fifty years ago, conceived the project of planting these dunes with pine forests, as a means of immobilizing the sand which, driven by the fury of the Atlantic gales, was continually encroaching more and more upon the country of the interior. A thick forest of these trees (Pinus Maritima) now covers the whole face of the country, and by these pine-covered sand-hills the site selected (in 1854) for the now well-known sea-coast resort of Arcachon is shut in and protected on every side except upon the north, which is occupied by the great salt-water lake above mentioned, upon whose southern shore the town is built.

From its close proximity to the Atlantic Ocean, Arcachon necessarily possesses a climate characterized by the moderate moisture of atmosphere, and by the equability of temperature proper to most maritime stations. The direction of the prevailing winds, which in this region blow from the ocean, is an important factor in insuring to this sea-coast station its proper maritime climate. From the direct violence of the Atlantic gales, as well as from the winds blowing from the east and south, Arcachon is sheltered by the dense pine forest which clothes the surrounding sand-dunes; while the sandy nature of its soil serves in some measure to diminish the tendency to excessive atmospheric humidity which might, perhaps,

be expected to exist in a region thus exposed to ocean winds.

Winds blowing from the north and from the northeast reach Arcachon after passing over its great lake or land-locked bay, the circumference of which is stated by Dr. J. H. Bennet to be sixty-eight miles in length. Such north and northeast winds, therefore, "become somewhat warmed in winter, and their irritating dryness diminished, while it is maintained that they also bring from the surface of this unusually salt sea-water, and from the vast extent of sands exposed by the retreating tides, an appreciable amount of saline and other marine emanations, to give a special efficacy to the air in certain scrofulous conditions." ("Health Resorts and Their Uses," by J. Burney Yeo, M.D., p. 261.) According to the author just quoted, the prevailing winds at Arcachon, namely, the sea-winds blowing from the northwest, west, and southwest, occur most frequently from December to February, "usually blow continuously day and night for several days in succession. . . . often blow with great violence, and, were it not for the protection of the lofty pine-trees . . . would form a serious drawback to the climate." The average number of rainy days in that portion of France in which Arcachon is situated, is stated by Lombard to be one hundred and thirty, while the total amount of the annual rainfall is twenty-three inches, a greater part of which falls during the winter and autumn months than during the spring and summer seasons.

The mean temperature for the year at Arcachon is 59° F.; the mean temperature of the winter season 46.4° F. to 50° F. (Lombard). At Bordeaux the mean winter temperature (according to the same author) is 43.7° F., and the mean annual temperature is 55.6° F. A very pronounced difference of temperature between these two points is thus made manifest, despite the trifling difference in latitude existing between them. According to data quoted from Dr. G. Hameau, in the "Dictionnaire Usuel des Sciences Médicales," the result of a series of thermometric observations taken in the pine woods at Arcachon, and covering a period of ten years, showed the mean annual temperature at 8 A.M. to be 55.76° F., and at noon to be 59.96° F.; for the minimum temperatures the annual mean was found to be 46.94° F.; for the maximum temperatures it was 66.2° F.

Arcachon is both a summer and a winter resort, and there are two distinct portions of the town, the one, adapted for residence during the warmer months, lying directly on the shore of the salt-water lake or basin, and possessing facilities for bathing; the other lying away from the water in the midst of the pine forest, separated from the shore town by a high sand dune, and consisting of "numerous villa residences actually built in the forest, each house being surrounded by pine trees" (Dr. J. Burney Yeo, op. cit.). This latter section is known as the Ville d'Hiver, or winter town, while the former is called the Plage, or beach. Of this Plage, Dr. Yeo remarks that it "is occupied by somewhat closely packed streets and houses," and becomes in summer time "a sort of Margate for the population of Bordeaux." Dr. J. H. Bennet says of Arcachon that it is "a pretty sea-side town . . . with good hotels, picturesque villas, convenient and handsome club-house and baths—indeed, all the appurtenances of advanced civilization. The summer town is built on the sandy shore of the great lake or sea, which affords excellent bathing. The lake itself, from its great extent and from its being land-locked on every side, offers every possible facility for safe boating, yachting, and fishing." After describing the Ville d'Hiver and giving much other interesting information concerning Arcachon in his entertaining book, "Winter and Spring on the Shores of the Mediterranean" (5th edition, 1875), and after alluding to the "rather mild and equable temperature" of the winter climate at Arcachon, to the advantage it possesses over Biarritz in being surrounded by pine forests affording "considerable shelter against wind for walks and drives," etc., etc., Dr. Bennet, nevertheless, expresses the opinion that the place has been overestimated as a winter residence for consumptives, and that it is not so favorable for this class of patients as is the Genoese Riviera. Dr. Sparks, in his article on the treatment of disease by climate, in Quain's "Dictionary," specifies Arcachon as a good resort for neuralgic patients. This place certainly presents to the invalid the rather unusual combination of a mild sea-side resort and of a pine woods sanitarium. The air of its surrounding forests is said to be remarkably rich in ozone, and is of course laden with the balsamic exhalations always to be found where trees of this species abound. According to Dr. Yeo the climate of Arcachon is "sedative yet not relaxing," is "mild," and is "especially suitable to cases of irritative bronchial or laryngeal catarrh, to cases of phthisis with tendency to congestion or inflammatory complications, and to persons of nervous temperament. It is not suited to persons of a lymphatic and torpid habit, who do better in the tonic and stimulating air of the Western Riviera. Cases of consumption and of other chronic lung diseases have certainly been arrested at Arcachon, and dyspeptic persons, in whom the dyspepsia has been complicated with hysteria, hypochondriasis, and nervous irritability, have derived great benefit from its climate" (J. Burney Yeo, op. cit., p. 262).

Huntington Richards.

ARCO. The village of Arco (Lat. 45° 52′ N., Long. 10° 52′ E.) is situated in the extreme southern portion of the Austrian Tyrol, about twenty-five or thirty miles from the Italian boundary line, and but three miles distant from the northern extremity of the beautiful Lago di Garda. Between the town and the shore of the lake extends a level alluvial plain hemmed in by lofty mountains on every side except the south, and traversed by the rivers Sarca and Varrone. Arco stands upon the western bank of the first mentioned of these two rivers, at the point where it emerges from between the hills. The elevation of the town above the lake is stated by Weber to be only 23 feet, while its height above sea-level is put by the same author at 240 feet (73 metres). In Eulenburg's "Real-Encyclopädie" the elevation of Arco above sea-level is given as 93 metres, or 305 feet. Directly behind the town, which nestles at its very foot, rises a bold rocky promontory some 400 feet high, upon which stands the old castle of Arco, surrounded by its gardens. The small level plain reaching from Arco southward to the lake is noted for its fertility, and produces very fine fruit; the grapes growing in this sheltered valley are very sweet, and the olive-tree, the fig, and the pomegranate also flourish. At Arco the orange ripens in the open air. Dr. Weber (Ziemssen's "Handbuch der Allgemeinen Therapie," B. II., S. 173) calls attention to the cultivation of the olive in this region, as proving that the temperature never sinks in winter below − 9° C. (= 15.8° F.); that, in point of fact, it seldom or never falls so low as this, will appear from the figures about to be quoted from Eulenburg's "Real-Encyclopädie." Although surrounded on the east and west as well as on the north by mountains, many of which have peaks rising to the height of 5,000 feet above the sea, the width of the little valley intervening between Arco and the lake is sufficiently great to prevent an overshadowing of the town by an east and west wall of lofty hills, and, as the country to the southward is all open, the rays of the sun have free access to this exceptionally sheltered spot during the greater part of the day. From the description given above of the topographical relations of Arco, it might naturally be inferred that severe winds would be debarred from access to the place, and that the town should by rights enjoy a good proportion of perfectly calm weather; and in fact it is celebrated, and justly so, for the calmness of its atmosphere during the greater part of the winter season.

In the months of December and January, and for the first half of the month of February as well, the atmosphere is, as a rule, quite undisturbed by winds. After the middle of February, however, and especially during the two months of March and April, the cold wind known as the "Bora" makes itself felt daily between the hours of 10.30 A.M. and 3 P.M., and may be expected to blow in this way for the next succeeding seven months, or until

the month of September (Eulenburg's "Real-Encyclopädie"). According to the authority just quoted, the mean annual relative humidity at Arco is 72 per cent.; the greatest number of rainy days occur during the two autumn months of October and November, and the two spring months of March and April, and such rainy days are characterized, for the most part, by the possession of a mild and equable temperature. This same writer accounts for the equability of the climate of Arco as being due in some degree to the nearness of the great Lago di Garda, a body of water some thirty odd miles in length from north to south, and whose southern extremity expands to a breadth of not less than ten miles; while the long, neck-like prolongation extending in a northerly direction from this great fresh water basin for a distance of some 20 or 25 miles, and walled in on either hand by the mountains of the Austrian Tyrol, has a width from shore to shore varying between 2 miles at its upper, or northern extremity, and 5 or 5½ miles at the point where it expands into the above-mentioned basin constituting the opposite and southern extremity of the lake. "In very severe winters," says the writer in Eulenburg, "the temperature does fall upon two or three occasions as low as 26.6° F. (−3° C.), or 24.8° F. (−4° C.), but this low temperature persists for a few hours only (*i.e.*, two or three hours), and occurs for the most part only very early in the course of the day (in den frühen Morgen-stunden)."

Dr. Weber (Ziemssen's "Handbuch der Allg. Therapie," B. II., S. 173) gives the following facts concerning the climate of the Italian Lake Region, and includes Arco in his list of places properly belonging within this climatic district. The relative humidity of such points he states as being between 72 and 78 per cent. during the autumn and winter months, and somewhat less than 70 per cent. in the spring season. The average number of rainy days is from 36 to 40 during the autumn, from 34 to 36 during the spring, and from 15 to 20 during the winter. Snow falls, as a rule, in this region, on not more than 6 or 8 days of the year, and seldom lies for several days together upon the ground. Among the local winds which prevail about all great lakes, those blowing from the north and from the northeast are of most frequent occurrence in this region. Fogs are rare; there are few days during which an invalid must keep within doors from sunrise to sunset; and there is less dust than is found along the Italian Riviera.

The following temperature chart is copied from Eulenburg's "Encyclopædia," to which book the writer is indebted for a large share of his information concerning the place in question.

OBSERVATIONS OF TEMPERATURE AT ARCO, WINTER OF 1875–76.
(From Eulenburg's Real-Encyclopädie.)

Month.	Monthly Mean.	Mean Max. (at noon).	Mean Min. (at noon).
October	59.5°	71.9°	52.2°
November	50.2°	60.8°	42.8°
December	41.8°	53.6°	42.8°
January	43°	61.7°	39.2°
February	45.3°	64.4°	41°
March	50.4°	66.2°	44.6°
April	59°	75.2°	50°

These figures, giving the result of one season of observations, speak for themselves, and indicate for Arco the possession of a mild and an equable climate during the seven colder months of the year.

Arco has come into notice quite recently as a desirable winter residence for invalids, the greater number of whom, according to the writer in Eulenburg, were, at the time when the "Real-Encyclopädie" was issued (1880), phthisical patients from North Germany. According to that writer, and to Dr. Weber, pleasant and comfortable apartments were already to be had at Arco for the accommodation of invalids, and a *Kurhaus*, with conveniences for baths, and provided with apparatus for the taking of inhalations, is mentioned by the former writer. The drinking-water is of good quality, and is derived from springs. The "cuisine" is German. Pretty walks abound in every direction, and, from its close proximity to the Tyrolean Mountains, and to Lake Garda, it is easy to understand that many delightful excursions may be made from the town. Although the writer of the present article is not in possession of definite information on this point, it is natural to infer that since the publication of the accounts of this resort from which such frequent quotations have been made, the arrangements at Arco for the accommodation of invalids must necessarily have increased in number; for there can be little question that Nature has endowed this spot with exceptional advantages as a winter health resort.

Huntington Richards.

ARCUS SENILIS. (SYN.: Gerontoxon, Gerotoxon, Kraus; Fr., *Arc Sênile, Gêrontoxon;* Ger., *Greisenbogen.*)

Arcus senilis is an elongated, narrow opacity of the cornea, situated close to the margin of the latter, in shape crescentic, or appearing under the form of two crescents, an upper and a lower; still more rarely, and in cases of extreme development of the lesion, consisting in a complete marginal ring produced by the coalescence of two such crescents. In color an arcus senilis varies according to the stage of its development; in slightly pronounced and recent cases the color is a faint grayish or milky white, in more advanced and severer cases the opacity becomes of a chalky whiteness. As its name implies, this lesion has been commonly supposed to belong exclusively to advanced life; such, however, is not the case: while it is indeed true that arcus senilis usually appears in persons over forty-five or fifty years old, nevertheless the eyes of many old people exhibit no trace of the lesion, and it is not very infrequently found in those under forty-five years of age, and in exceptional cases has been observed during youth: a very few congenital cases have even been reported (by Wardrop, Withusen, and Morhenheim). A strip of transparent, or nearly transparent tissue, almost always exists between the outer margin of an arcus senilis and the extreme periphery of the cornea: this strip is usually about one millimetre wide. (Where arcus senilis is the result of repeated attacks of keratitis in persons under forty years old, this clear space does not exist: it was also absent in the congenital cases above alluded to.) Except in very slightly marked and recent cases of this lesion, two crescents will be found, the upper one being always the first to appear and being invariably the more advanced of the two in its development. Thus the upper crescent is always more opaque, wider, and longer than the lower one. The centres of the two crescents may always be joined by a straight line passing through the middle of the pupil, and this straight line is usually a vertical one, although at times it may be slightly inclined. The greatest degree of opacity in each crescent is found either at, or slightly external to, its middle point, and from this centre the opacity shades off gradually toward the outer and inner extremities, more gradually toward the latter than toward the former. Arcus senilis increases more rapidly in opacity than in width; its central and peripheral borders are well defined, the peripheral border especially so. The lesion is seldom more than three millimetres wide at its widest point. Arcus senilis is usually bilateral, although one eye alone may be affected. The growth of an arcus senilis is accelerated by the existence of deep-seated disease of the eye.

PATHOLOGY.—The pathological condition consists essentially in a fatty degeneration of the cornea, affecting primarily the corneal corpuscles, subsequently the lamellæ of the intercellular substance in the superficial layers of the substantia propria; in severe cases spreading to the deeper layers, even down to the membrane of Descemet, and, exceptionally, appearing in Bowman's membrane and in the epithelial layer which covers the latter. "In great senescence, however, a very similar layer-like disposition of molecular fat has been seen in the bordering zone of the conjunctiva and sclera, and even in the ciliary muscle and processes, with atheromatous degen-

eration of the corresponding vessels" (Stellwag on the Eye).

The results of the most careful observations, both clinical and pathological, would seem to show that an arcus senilis is a frequent accompaniment of degenerative changes in the ophthalmic and other branches of the internal carotid artery; in fact, that it is preceded by such changes, and follows as an effect of them. By some it has been regarded as a lesion almost pathognomonic of fatty heart; this, however, is too much to assume, for arcus senilis has been seen in persons who had not fatty degeneration of the heart, and fatty heart can exist without arcus senilis; although it yet remains true that, in a patient presenting an arcus senilis together with indications of enfeebled action of the heart, we are warranted in strongly suspecting the presence of a fatty degeneration of this organ. From the observed fact that an atheromatous degeneration of some of the cerebral vessels has been found to accompany the lesion under discussion (Canton, Schoeen, J. Arnold), we are justified in regarding with suspicion the occurrence of arcus senilis in persons under forty years old, such persons being, not improbably, exposed in an unusual degree to the dangers of cerebral hæmorrhage and softening.

Symptoms.—Of symptoms arcus senilis has none, and but one case is recorded where the opacity was sufficiently extensive to interfere with vision.

Ulceration of the cornea, when it involves the area of fatty degeneration occupied by an arcus senilis, is exceedingly rebellious to treatment; on the other hand, a clean-cut incision through the degenerated tissues, as practised in the operation for cataract, heals as rapidly as in a perfectly normal cornea. In persons of a broken-down constitution it is said that an arcus senilis offers a very inviting field for ulcerative changes.

Treatment.—There is no curative treatment for arcus senilis; it may, however, be possible, by a course of general treatment directed against the disease acting as prime factor in the case, to arrest the development of the lesion (as in a case alluded to by J. F. Streatfield in Quain's "Dictionary of Medicine"). *Huntington Richards.*

AREA EMBRYONALIS—PELLUCIDA—VASCULOSA, Etc. In eggs which contain a great deal of yolk, as in those of birds, we often see an apparent separation of the ovum into two parts, one the embryonic portion in a strict sense, and the other the extra-embryonic portion or yolk sac. The term *area germinativa*, or *embryonalis*, or its synonym the germinal disk, is used to designate that portion of the ovum which is most immediately concerned in the construction of the embryo. In the *area germinativa* there is a central portion known as the *area pellucida*, from its clear appearance, and an outer broad margin of a darker hue, known as the *area opaca*, or *vasculosa*, because the first blood-vessels are developed in this region. In the centre of the area pellucida appears a longitudinal mark, the primitive streak, which shows the position of the median longitudinal axis of the embryo; at this time the *area pellucida* is oval, the large end extending around the cephalic extremity, and is completely surrounded by the broad *area opaca*, the outside boundary of which is nearly circular. The cause of the difference in transparency between the two areas lies in the character of the inner or entodermal lamina of cells,—the entoderm of the pellucida is a very thin epithelium, somewhat resembling the so-called endothelium of the adult peritoneum, while the entoderm of the opaca is an epithelium composed of very large cells with small nuclei and very numerous granules, which were included from the yolk when those cells were segmented off. Toward the periphery of the *area opaca* the entoderm becomes thicker and passes over without any recognizable demarcation into the yolk; around the edge of the area embryonalis, then, there is a thickened rim of material underlying the ectoderm; this is known as the germinal wall (*Keimwall*); it contains cells and nuclei and yolk granules, and passes on the one side into the distinctly epithelial entoderm, on the other into the still unsegmented yolk; it is the site of rapid cell production, so that the area embryonalis enlarges rapidly by peripheral additions; on the inner margin of the opaca the cells are thinned out, and thus the pellucida constantly encroaches upon the opaca—the former grows at the expense of the latter. It should be remembered that in both parts there is an interstitial growth, effected by the divisions of the cells composing them.

Our knowledge of the nature of the "Keimwall" is thus summarized in Foster and Balfour's "Embryology" (Second edition, pp. 65, 66), reference being had especially to the chick. "The exact nature of this material has been the subject of many controversies. Into these controversies it is not our purpose to enter, but subjoined are the results of our own examination. The germinal wall first consists, as already mentioned, of the lower cells of the thickened edge of the blastoderm, and of the subjacent yolk material with nuclei. During the period before the formation of the primitive streak, the epiblast (*i.e.*, ectoderm) appears to extend itself over the yolk, partly at the expense of the cells of the germinal wall, and possibly even of the cells formed around the nuclei in this part. The cells of the germinal wall, which are at first well separated from the yolk below, become gradually absorbed in the growth of the hypoblast (*i.e.*, entoderm), and the remaining cells and yolk then become

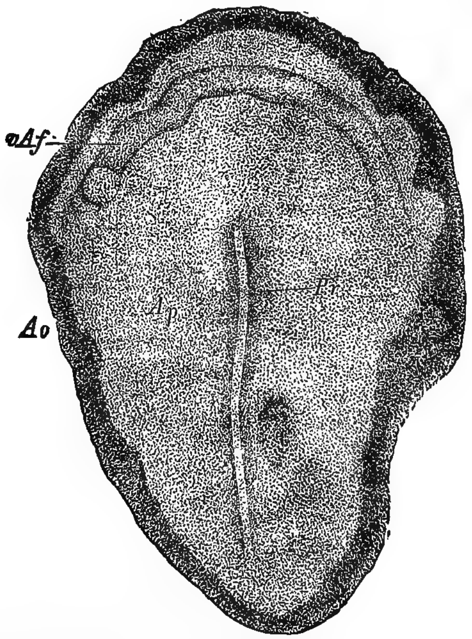


Fig. 229.—Surface View of the Embryo Chick, Incubated about Twenty Hours. The whole of the area pellucida, *Ap*, and a small part of the area opaca, *Ao*, is shown; *Pr*, primitive groove; *vAf*, anterior or cephalic amniotic fold.

mingled together and constitute a compound structure, continuous at its inner border with the hypoblast (entoderm). This structure is the germinal wall usually so described. It is mainly formed of yolk granules with numerous nuclei, and a somewhat variable number of rather large cells embedded among them. The nuclei, some of which are probably enclosed by a definite cell-body, typically form a special layer immediately below the epiblast. A special mass of nuclei is usually present at the junction of the hypoblast with the germinal wall." A simple and natural interpretation of the germinal wall is to regard it as the zone of segmentation around the embryonic area, where new cells are being segmented off from the yolk and added to the germinal disk proper. The course of segmentation in the ova of bony fishes seems to me to settle beyond reasonable doubt the justice of this interpretation; in these ova it is readily seen that the growth of the germinal disk is exactly as just stated—by peripheral addition of cells segmented off from the

yolk. A much discussed problem is thus solved. Kollmann's account [8] of the exact arrangement of the parts in the germinal wall differs in some important respects from that of other authors, but probably makes a real advance in accuracy. His statements do not conflict with the conception of the nature of the germinal wall advanced in this article.

If the germinal area of a hen's ovum, at about the stage shown in Fig. 229, be removed from the yolk, hardened, and transverse sections made through it, the three primitive germ-layers will be found already present, as is shown

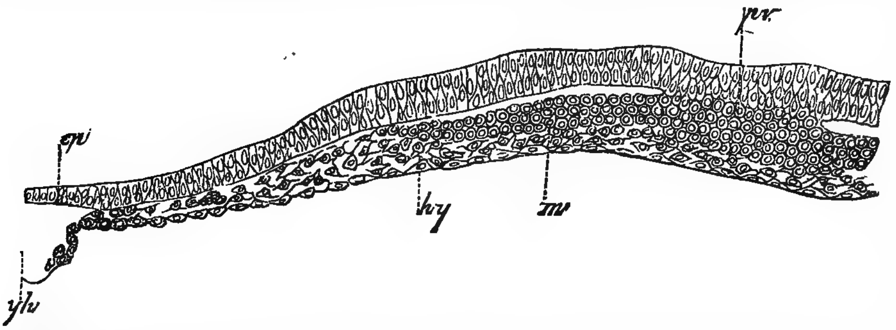


FIG. 230.—Transverse Section through the Front end of the Primitive Streak of a Germinal Area of a Hen's Ovum, about Eighteen to Twenty Hours. (After Foster and Balfour.) *pv*, primitive streak; *ep*, ectoderm; *hy*, entoderm; *m*, mesoderm; *gh*, germinal wall.

in the accompanying wood-cut of such a section through the anterior end of the primitive streak. The outer layer is thick, the inner layer thin and scarcely differentiated from the middle layer, which consists of loose scattered cells.

We have thus briefly indicated the characteristics of the area embryonalis at the time of the appearance of the primitive groove. Its origin is described under Segmentation; the nature and significance of the primitive streak is treated under Fœtus. We proceed now to the further

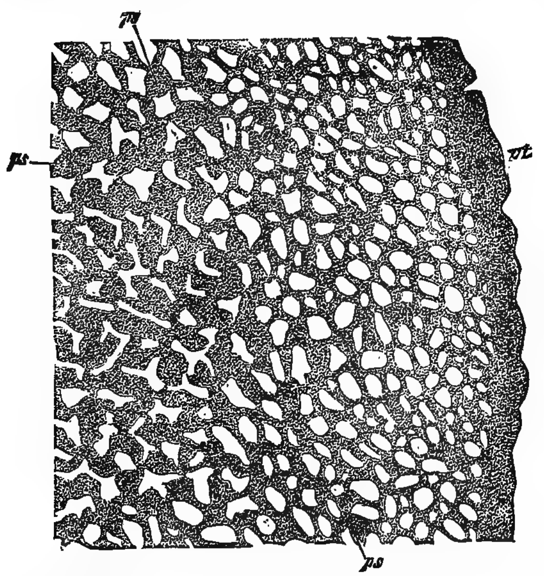


FIG. 231.—Part of Area Vasculosa of Embryo Chick of Forty Hours. (× 26 diam.) (After Kölliker.) Only the vascular network is drawn, *ps*, and the terminal sinus or vein, *vt*.

history of the germinal disk in meroblastic vertebrates, and shall close the article with an account of the area in mammalia; we omit here, of course, the history of the differentiation of the embryo in the area pellucida, as that history is fully treated under Fœtus, and confine our attention to the changes in the extra-embryonic portions.

The *area germinativa* presents in all vertebrates a nearly circular outline; at first it occupies a small space on top of the yolk, but it gradually expands on all sides, spreading further and further; in time it reaches the equator of the yolk, and then expands so as to encroach upon the inferior hemisphere, and apparently continues its growth until it reaches the inferior pole and the yolk is completely enclosed; this expansion is due, as we have seen, to the peripheral accretions made by the germinal wall. Most of the enlargement falls to the share of the area opaca, because the additions to its outside rim are more rapid than the conversion of its inner edge into the area pellucida, which therefore expands more slowly. The pellucida changes its shape during its development; at first it is quite round, it then becomes elongated and soon pear-shaped (Fig. 229). In the chick the broad end of the pear widens rapidly, and is well marked off from the narrow end which surrounds the caudal extremity of the embryo.

The most important function of the extra-embryonic area is the formation of the blood-vessels and blood. The first appearance of these organs is in the mesodermic splanchnopleure of the area opaca; they are next developed in the area pellucida, and finally in the embryo proper. H. Strahl states that in the lizard the blood and blood-vessels first appear in the area pellucida. Toward the edge of the area, however, the vascular layer is so thick that it may appear as if the whole mesoderm participated in the formation of the blood-vessels; but wherever the mesoderm has split, the blood-vessels lie in the lamina next the entoderm, *i.e.*, in the splanchnopleure. In the chick, by the second day,

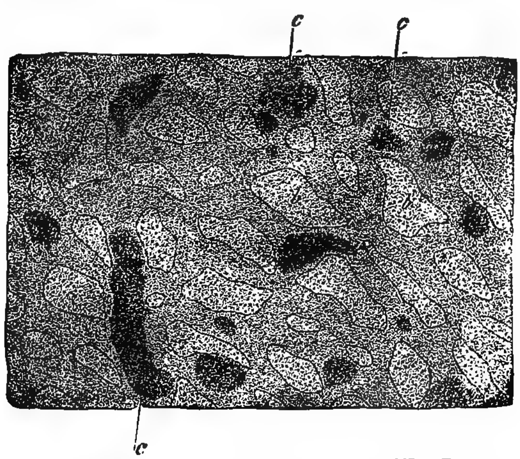


FIG. 232.—Vessels of the Area Pellucida of a Chick of Two Days. *a, a*, vessels; *b, b*, interstitial tissue; *c, c*, blood-islands. (After Kölliker.)

the vessels form a coarse network, Fig. 231, without any indication of large stems or trunks, except the broad limiting sinus *vt*, which marks off the edge of the area. There is only one layer of vessels. Scattered about in the network are irregular red spots, which received from early embryologists the name, still current, of blood-islands. At first the network consists of solid cords of cells, but the cords are soon hollowed out, becoming tubes with endothelial walls; but exactly how this is accomplished is not yet clear. The blood-islands give rise to the first colored blood-corpuscles, which are not identical with the red globules of the adult, being colored

nucleated cells, and arising, according to Kölliker, by direct metamorphosis of the mesodermic cells of the primitive vascular cords. The structures thus briefly described are the *primary vascular "Anlagen;"* the *secondary* are different, consisting of fine single or double rows of cells, which afterward become hollowed out, canalized

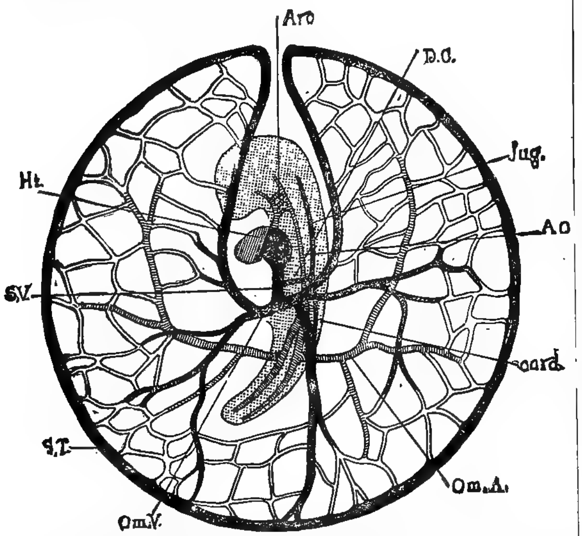


FIG. 233.—Diagram of the Circulation in a Chick at the End of the Third Day, as seen from the Under or Ventral Side. The embryo, with the exception of the heart, Ht., is dotted; Arc., aortic arches; D.C., ductus Cuvieri; Jug., jugular vein; card., cardinal vein; the remaining letters are explained in the text. The veins are black; the arteries cross-lined.

into endothelial tubes, while blood-corpuscles are formed in their interior. These fine cords grow into the area pellucida, and so into the embryo, according to His, [2, 4, 5, 6], who maintains that all the embryonic blood-vessels grow in from the extra-embryonic area, and that the connective-tissue also grows similarly. Hence His distinguishes between the tissues originally present in the embryo (*Archiblast*) and those which grow into it (*Parablast*). It is still undecided how far these views will hold; they have been the subject of much discussion, but it will suffice to refer now to the papers of Waldeyer [7] and Kollmann, [8], [9].

We give here Schaefer's account of the development of the *secondary vascular "Anlagen,"* within the body of the embryo. "One of the most favorable objects for the study of the development of the blood-vessels and their contained blood-corpuscles, is afforded by the subcutaneous tissue of the new-born rat, especially those parts in which fat is being deposited. Here we may observe that many of the connective-tissue corpuscles are much vacuolated, and that the protoplasm of some of them presents a decided reddish tinge. In others the red matter has become condensed in the form of globules within the cells, varying in size from minute specks, to spheroids of the diameter of a blood-corpuscle or more. . . . After a time the cells become elongated and pointed at their ends, sending out processes to unite with neighboring cells. At the same time the vacuoles in their interior become enlarged, and coalesce to form a cavity within the cell, in which the reddish globules, which are now become disk-shaped, are found. Finally, the cavity extends through the cell processes into those of neighboring cells, and into those sent out from pre-existing capillaries; but a more or less extensive capillary network is often formed long before the connection with the rest of the vascular system is established." The corpuscles thus formed are identical with the adult red globules, and different from the red cells, produced as above described in the blood-islands. The former gradually replace the latter, which nearly all disappear long before the end of intra-uterine life in the human species, although, according to Neumann, some are still to be met with even in the new-born child. How the red cells disappear is unknown. Hayem [13] claims to have found red nucleated cells in the adult, but they are probably pathologically modified leucocytes, and not survived embryonic red cells, as they were found only in persons with certain severe diseases. (The best general account of the origin of the blood is in Quain's "Anatomy" (Ninth ed., p. 34, ff.), where the literature is given *in extenso.*) Three kinds of corpuscles appear in the blood of the amniota: 1, red cells, probably homologous with the nucleated red globules of amphibia; 2, white corpuscles or cells; 3, true red globules, not cells.

Feuerstack [14] has attempted to trace the formation of all colored blood-corpuscles in vertebrates to the direct metamorphosis of colorless corpuscles (leucocytes). It is probable that he is correct as far as the nucleated red blood-globules of amphibia and amniote embryos are concerned. But, as stated just before, the true red globules of the higher vertebrates are new acquisitions by them, and, as far as we know at present, have no homologue in amphibia. Feuerstack has entirely overlooked this conclusion. Besides the view given above and adopted by Schaefer, as to the origin and nature of the red blood-globules, is another (Balfour, [10] Kultschitzki, [15] *et al.*), according to which the nuclei in the parent cells multiply, and becoming charged with hæmoglobin are converted into blood-globules which are set free by the breaking down of the parent-cells. There is much to be said in favor of this interpretation, which will, perhaps, be found correct when the extension of knowledge shall have settled the problem.

Soon after the capillary network of the area opaca and pellucida has penetrated the embryo, certain lines of the network begin to widen, and soon distinctly assume the size and functions of main trunks; some of these unite with the posterior venous end of the heart, which has meanwhile been formed in the embryo, and others become connected with the anterior or aortic end; even

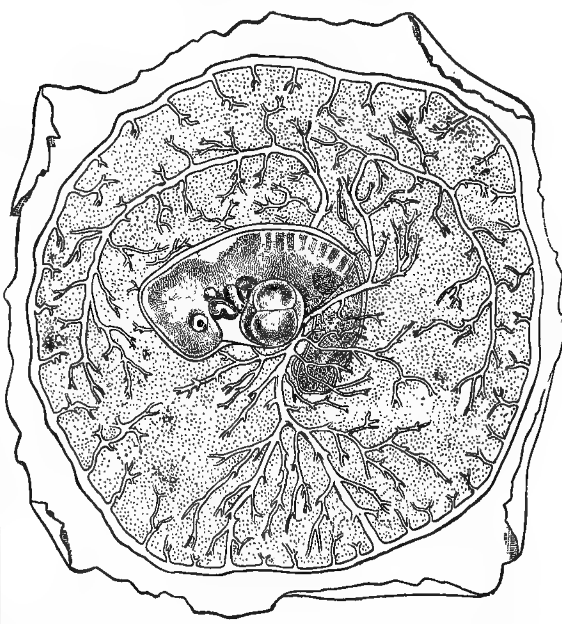


FIG. 234.—Area Vasculosa and Embryo of a Rabbit. (After Van Beneden and Julin.)

before this the heart has begun to beat, so that as soon as all the connections are made, the primitive circulation starts up. The arrangement of the vessels is not the same in birds and mammals, although commonly so stated. The disposition in birds is indicated by the diagram shown in Fig. 233, in which, it should be remembered, the embryo

Area Embryonalis.

and the capillary network are drawn many times too large in proportion to the *area vasculosa.* The area is bounded by a broad circular vessel, the sinus terminalis, S.T., which constitutes a portion of the venous system in birds, for in front of the head of the embryo the sinus leaves a gap and is reflected back along the sides of the body of the embryo, to make two large veins, which, after uniting with other venous channels coming from various parts of the area vasculosa on each side, enter the embryo as two large trunks, Om.V., known as the *omphalo-mesaraic veins ;* these two veins unite in a median vessel, the *sinus venosus*, S.V., which runs straight forward and enters the posterior end of the heart. The sinus venosus also receives the veins from the body of the embryo, namely, the jugulars, *jug.*, and cardinals, *card. ;* the former from in front unite each with the cardinal of the same side, making a short transverse trunk, known as the *Ductus Cuvieri*, D.C. ; the two ducts empty into the sinus venosus. The entire venous current is thus brought to the heart in a united stream ; it passes out through the aorta ; the greater part ascends the aortic arches and passes back as shown in the figure, Ao., and divides at the posterior fork of the aorta, the bulk of the two currents passing out through the omphalic arteries, Om.A., and thence into the capillaries of the *area vasculosa*, and so on to the venous trunks again. As shown in the figure, which presents the underside of the area, the left omphalo-mesaraic vein preponderates, and in the latter stages this difference becomes more marked, until finally the right stem is very inconsiderable in comparison with the great left vein. The time at which the disparity commences is extremely variable, as is also the degree of inequality between the two veins.

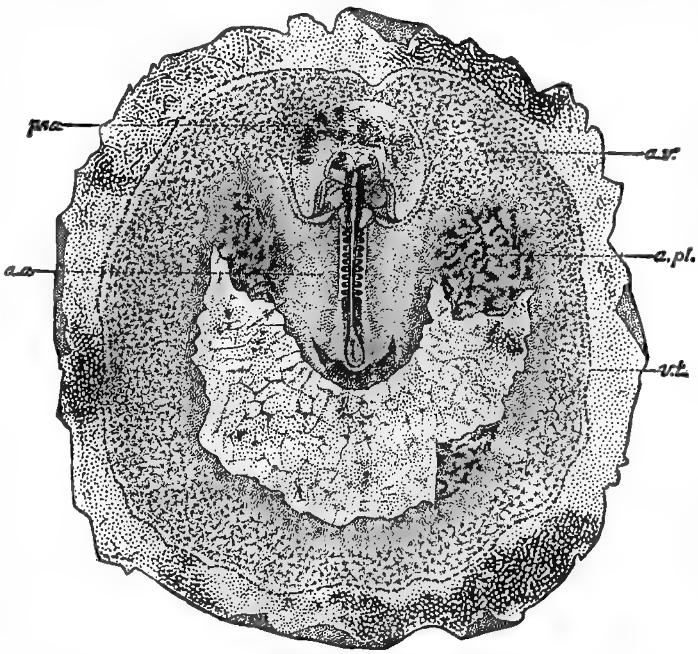


FIG. 235.—Area Embryonalis of a Rabbit of Eleven Days, with the Area Placentalis partly torn off. (After Van Beneden and Julin.) *pr.a.*, pro-amnion ; *a.a.*, area amniotica ; *a.v.*, area vasculosa ; *a.pl.*, area placentalis.

According to Van Beneden's [12] recent researches on the rabbit the arrangement of the main vessels in the area vasculosa of mammals is quite different. The sinus terminalis forms a *complete* ring and is connected with the *arterial* system by a single trunk, which corresponds to the left omphalic artery of the bird. For some time the connection between the embryonic arteries and the area vasculosa is entirely through capillaries, and the arterial trunk on the vascular area does not appear in the rabbit for several days. There are two veins, one arising from each side of the body and passing out on to the area vasculosa over the back of the embryo ; they are the two large upper vessels in the figure.

In the mammalian ovum we have further to distinguish the *area placentalis*, that portion of the chorion by which the embryo is attached to the uterine wall, and which afterward participates in the formation of the placenta. Whether this exists in all mammalia distinctly marked out during very early stages is uncertain, but in some species, at least, it is present at an extremely young stage. It is not safe to speak at present in general terms of the divisions of the area embryonalis in mammals ; we confine ourselves, therefore, to a description of the divisions in the much-studied rabbit, following in this the last publication [12] of Van Beneden and Julin. The germinative area, Fig. 235, is nearly circular, and at the stage figured shows the following peculiarities : The nearly straight embryo lies in the centre, and exhibits plainly the central nervous system and the proto-vertebræ ; around the head of the embryo is a clear space, *pr.a.*, the pro-amniotic area, over which no mesoderm is developed ; around the sides and hind end of the embryo is another light place which contains mesoderm, but is distinguished by the retarded vascularization ; this is the amniotic area, *a.a.*, and is converted, by a process of upfolding similar to that described above in reference to the chick, into the amnion, which, as previously stated, covers the posterior portion of the rabbit embryo. The remainder of the germinal disk constitutes the area vasculosa, *a.v.*, with the terminal sinus, blood-islands, etc. The area consists of two membranes, the upper the somatopleure, the lower the splanchnopleure ; a large portion of the former behind the embryo has been torn off, *a.pl. ;* this defect is due to the fact that over this region villosities have appeared, and a close connection established between this region and the uterine wall ; it is by this means that the ovum is attached ; hence, when the embryo is removed from the uterus, this area of the splanchnopleure (chorion) remains adherent to the uterus. As development proceeds, the allantois grows up against this area, over which the differentiation of the placenta takes place ; hence the name, area placentalis.

NOTE. — Since this article was put in type, I have seen an extended article by Duval on the structure of the embryonic area (*Annales des Sciences naturelles*, Zoologie, 1885, numéro 1). He has studied the germinal wall with detail and reports results of great interest, especially as concerns the growth of the area and the first appearance of the embryo. His conclusions will be discussed under Fœtus.

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Charles Sedgwick Minot.

ARECA NUT (*Areca*, Br. P., Betel Nut). The Areca Palm, *Areca Catechu* Linn., is a fine large tree, with smooth, graceful stem and a handsome crown of long pinnate leaves. The flowers are monœcious; the fruit is egg-shaped, with a fibrous mesocarp and a hard stone consisting of the seed and adhering endocarp. It is from fifty to seventy-five centimetres (two to three inches) long. The albumen is hard, ruminated, and contains a minute embryo near the base. This tree is a native of India, the Sunda Islands, and probably of other neighboring parts. It is cultivated there and elsewhere in the tropics for the sake of its seeds, which have been an article of Asiatic commerce for centuries. There is still an enormous consumption of them in China and India, chiefly as a masticatory; for this purpose they are boiled or used when fresh and soft. They are often chewed with the leaves of the Betel Pepper and lime. Their introduction into European medicine is rather recent.

Areca nuts of our market consist of the kernel of the seed only, the testa being removed with the pericarp. They are about two centimetres in diameter, and about as long as broad. Their shape is between spherical and conical, with a very blunt rounded point, and a broad, flat, or sometimes depressed base. The surface is of a cinnamon-brown color, and covered with a network of vein-like lines, which radiate irregularly from the base toward the apex. The albumen is very hard and bone-like, and upon being sawed through presents a marbled surface like that of the nutmeg, caused in the same way, that is by the infolding of the brown surface-layer of the seed (endosperm), which takes place under the reticulated lines above described. The general color of the section is whitish, the lines are brown.

The principal constituents, as given by Professor Flückiger, are: a red *tannic matter*, giving a green color with persalts of iron, and resembling Rhatania- or Cinchona-red, and a solid *fat*; of each fourteen or fifteen per cent. The tænicide principle has not been determined.

Areca is an efficient astringent and has no unpleasant taste or smell, but it has no medicinal advantage over the numerous other tannin-containing articles in more general use. The charcoal made by incinerating the nuts is used as a dentifrice. It is only seriously employed in medicine as an anthelmintic, especially as a tænicide—even for this purpose but rarely, although it has undoubted power.

Dose.—From four to sixteen grams (ʒ j. to ʒ iv.), in powder.

ALLIED PLANTS.—The order *Palmæ*, from an economic as well as botanical point of view, is one of the most interesting in the whole vegetable kingdom, but as its products have almost no medical importance, much space cannot be given to it in this work. The following short list of some of its best-known species will illustrate the variety of its products:

Areca Catechu Linn.	
Phytelephas macrocarpa R. and P., etc.	Vegetable Ivory.
Phœnix dactylifera Linn.	Dates.
Calamus Rotang Linn., etc.	Rattan.
Calamus Draco Willd	Dragon's Blood.
Metroxylon Rumphii Mart., etc.	Sago.
Saguerus saccharifer Bl., etc.	Sago and Syrup.
Cocos nucifera Linn., etc.	Cocoanuts, etc.
Elaias Guineensis Linn	Palm Oil.

Etc., etc.

Besides these, it furnishes coarse and fine woods for all purposes, materials for ropes, vessels, hats, fans, chairs, cloth, cups, various kinds of instruments, wax, foods, drinks, and wines, etc., and luxuries in great variety. The Cocoanut tree alone supplies a greater number of the material wants of mankind than any other plant.

ALLIED DRUGS.—See NUTGALLS for Astringents, Koosso for Anthelmintics. *W. P. Bolles.*

ARENARIA RUBRA, *Codex Med.; Spergularia rubra* Pers.; Order, *Caryophyllaceæ*. The entire plant of this little widely dispersed weed is official in France. It may be used freely in decoction for vesical catarrhs, etc., but has no well-defined medical qualities or active constituents, and is as unworthy to be ranked as a medicine as its near relative Chickweed would be.

The entire order is particularly destitute of active properties and furnishes no important food, medicine, or poison; but it does grace our flower-gardens with some of their choicest treasures. The glucoside *Saponin* occurs in a number of its species. See SOAPWORT.

ALLIED DRUGS.—See COUCH GRASS. *W. P. Bolles.*

ARGYRIA. The discoloration of the skin resulting from the internal use of nitrate of silver. It shows itself first as a faint steel-gray, or pale-bluish color, appearing earliest upon the face, hands, and other uncovered portions of the body, where also, even when the rest of the body is invaded, the most intense discoloration is to be found. If the medicament is continued the discoloration deepens in intensity, until it is a dark-grayish blue. The mucous membranes are involved, the mouth and conjunctiva becoming discolored. The nails show some discoloration, and the hair sometimes assumes a reddish tint.

Microscopical examination of the skin in argyria shows the epithelial layer, the rete, and the glandular epithelium all free from infiltration by the silver, while collections of the coloring matter are found in the connective-tissue of the skin. These deposits are most dense in the upper portion of the papillæ and in the membrana propria of the sweat-glands, where they present under a low microscopic power the appearance of a thin violet line. Deposits also may occur in the various internal organs, with the exception of the nervous system.

The appearances seen in argyria may occur after long-continued use of nitrate of silver, or after a brief use of large doses of the drug.

Argyria has usually been regarded as incurable. Dr. L. P. Yandell, however, has reported two cases in which relief and cure were obtained by the employment of ten to sixty grain doses of iodide of potassium thrice daily for months, together with mercurial vapor baths. The patients were syphilitic. *Arthur Van Harlingen.*

ARIZONA. The exceptional dryness and purity of its atmosphere, the wonderful clearness of its skies, and the very small number of rainy days there occurring, would all seem to point to the desirability of the Territory of Arizona as a health-resort for patients suffering from pulmonary phthisis or from other diseases of the respiratory system.* Owing, however, to the unsettled condition of the country at the present time, and to its great distance from the centres of civilization, it can hardly be expected that proper living accommodations and food should be found in Arizona for any save such invalids as are fully able to put up with a rather coarse and meagre dietary, and to brave the other discomforts incident to frontier life. The climatic advantages of Arizona are almost identical with those to be found in New Mexico, and for their more detailed discussion the reader may be referred to the articles on New Mexico and Santa Fé, to be found in later volumes of the HANDBOOK.

A writer on the climatic advantages of this region, whose residence as post-surgeon at Fort Apache, in the eastern part of Arizona, entitles him to be listened to as one

* According to the mortality statistics given in the compendium of the Tenth Census of the United States (1880), the number of deaths occurring *from all causes* in Arizona, during the census year, was 291; while the number set down as due to *consumption* during the same period is only 18: the percentage of deaths from consumption was therefore only 6.2 per cent. The actual number of deaths from this cause per 10,000 of total population was 4.45, a lower figure than we find for any other State or Territory in the Union with the exception only of New Mexico and of Wyoming.

whose opinions are based upon the authority of personal observation, has called attention to the prevailing absence of pulmonary phthisis and of pneumonia among dwellers in this section of country. At Camp Apache, this writer tells us, "the winters are sometimes harsh, the thermometer occasionally registering as low as 6° F., with considerable rain and snow: yet when the days are clear the temperature is mild and bracing." The summer climate at this elevated station (Camp Apache stands 5,600 feet above sea-level, despite the fact of its lying in a valley) he describes as delightful. "From May to December the climate is superb, the temperature rarely reaching 100° F. at noon, and generally falling to about 70° F. at night, causing a blanket to be comfortable and refreshing sleep certain. This summer the snow did not disappear from the mountain-tops until the middle of June, and the so-called 'rainy season' commenced about the 1st of July and lasted until September 1st. During this period frequent showers with vivid lightning occur, leaving the day bright, with a delightful atmosphere." The same writer says that he has found phthisical patients able to bear very well the great changes of temperature incident to a region having so exceptionally dry an atmosphere as that of Arizona, provided that they do not expose themselves to moving currents of air. (See "Arizona Territory as a Health-Resort for Consumptives," by B. G. McPhail, Post-surgeon U. S. A., Camp Apache, Arizona, in the *Virginia Medical Monthly* for December, 1874.)

A glance at the hypsometric map of the United States, to be found in the U. S. Census for 1880, will show that fully seven-eighths of the Territory of Arizona has an elevation above sea-level of more than 500 feet, while for perhaps two-thirds of the Territory the height above the sea may be set down as varying from 2,000 to 6,000 feet. The greatest elevations lie toward the north and east, the least toward the south and west. For detailed statistics of the climate of one of the exceptionally low-lying stations of Arizona the reader is referred to the chart given under the title Yuma, in the last volume of this HANDBOOK.

The three tables given below, and marked respectively A, B, and C, are extracted from more extensive tables in "Smithsonian Contributions to Knowledge," Nos. 277 and 222. The figures in these tables will serve to give a more accurate idea of the climate of Arizona than any that could be conveyed by a merely descriptive account of the Territory, based, as the latter would have to be, upon rather scanty sources of information.

Table A shows the mean temperature of the months, of the seasons, and of the year, for each of the four stations selected. In Table B are given the extremes of heat for each month occurring during a year of extreme heat, and the extremes of cold occurring during a year showing exceptional extremes of low temperature; such years of extremely high and of extremely low temperatures being selected out of the total number of years comprising the period of observation at each station. Concerning this table of extreme temperatures it is important to remark that in the series from which they are taken the values of the figures given are not claimed to be absolute, but only approximative, being based, almost without exception, upon data from the tri-daily observations at each station, and not upon observations with the maximum and minimum thermometers. The hours, also, of such tri-daily observations at each of the four stations here considered were those of 7 A.M., 2 P.M., and 9 P.M. Table C shows the mean amount of precipitation in rain or melted snow at each of the four selected stations.

The figures of these three tables not only show the extreme heat which, during the summer season, is liable to prevail in nearly all parts of Arizona, and the great variability of the climate in point of temperature at all seasons; but they also demonstrate, in some measure, the differences in climate, depending upon altitude rather than upon latitude, which are met with in different portions of

TABLE A.

Name of Station.	Lat.	Long.	Height above sea-level.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Sum.	Aut.	Wint.	Year.	Series. Begins.	Series. Ends.
Fort Mojavé.......	35°06′	114°35′	604	52.23	56.43	64.06	73.67	80.38	90.02	94.51	93.25	84.15	74.84	61.73	53.50	72.70	92.59	73.57	54.05	73.23	June, 1859.	Dec., 1870
C'p Lowell, Tucson	32°13′	110°53′	*	49.16	50.89	58.77	67.11	76.58	85.54	87.04	83.98	80.77	72.19	61.41	50.67	67.49	85.52	71.46	50.24	68.68	Nov., 1866.	Dec., 1870
Camp Date Creek...	34°18′	112°40′	3,726	43.52	47.35	51.73	61.49	70.38	81.16	83.69	81.66	76.41	63.48	53.21	45.71	61.20	82.17	64.37	45.58	63.32	May, 1867.	Dec., 1870
Fort Canby........	35°43′	109°10′	6,500	24.04	31.29	39.50	47.30	54.58	67.22	70.51	67.69	58.64	47.36	37.57	26.37	47.13	68.47	47.86	27.23	47.67	Dec., 1851.	Nov., 1863

* Elevation of Tucson is given in Report of Chief Signal Officer, U.S.A. (1881), as 2,404 feet.

TABLE B.

Name of Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year of extreme heat. Do. of extreme cold.	Series. Begins.	Series. Ends.
Fort Mojavé........	78	83	92	100	110	117	118	116	109	105	90	81	1870 & 1873	Jan., 1860.	June, 1864
	21	14	36	40	47	39	47	52	45	27	20	23	1873†		
Camp Lowell, Tucson	76	82	93	98	102	111	112	102	101	96	98	78	1869	Nov., 1866.	Dec., 1870
	22	22	27	36	52	53	72	70	62	40	31	20	1869		
Camp Date Creek....	73	84	86	92	101	108	111	105	106	97	86	84	1870	Aug., 1867.	Dec., 1870
	20	22	25	38	45	48	65	58	52	32	27	16	1869		
Fort Canby..........	63	61	76	80	89	98	99	96	87	79	72	65	1855	Dec., 1851.	Nov., 1863
	−20	−12	−1	12	19	30	36	43	30	17	0	−25	1855		

† In explanation of the discrepancy between these figures and those standing in the column next following, it may be remarked that in the text preceding these tables in Smithsonian Contributions to Knowledge, No. 277, it is stated "Observations of a later date than 1870 are included in our table."

TABLE C.

Name of Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Sum.	Aut.	Winter.	Year.	Series. Begins.	Series. Ends.
Fort Mojavé......	0.51	0.25	0.25	0.05	0.00	0.03	0.04	0.01	0.07	0.00	0.88	0.42	0.30	0.08	0.95	1.18	2.51	Aug., 1859.	Oct., 1866
Camp Lowell, Tucson.........	....	....	...	....	0.00	0.00	2.90	1.40	0.60	....	....	1.70	....	4.30	....	....	......	1867	
Camp Date Creek...	....	....	....	....	0.13	0.00	2.81	1.23	0.18	0.03	0.98	4.09	....	4.04	1.19	....	......	1867	
Fort Canby.....................	0.98	0.70	0.84	0.67	0.52	0.74	2.44	2.73	1.86	0.70	1.16	0.87	2.03	5.91	3.72	2.55	14.21	May, 1852.	Dec., 1860

the Territory. It should always be borne in mind that in a country having so extraordinarily dry an atmosphere as that of Arizona, extremes, both of heat and of cold, are far less felt than they are in regions where the relative humidity of the atmosphere is considerably higher.

Huntington Richards.

ARM, Applied Anatomy of. The *arm* or *upper arm* extends from the lower border of the pectoralis major to a point about four centimetres (one and a half inch) above the bend of the elbow.

The *shape* and outlines of the arm depend upon the age, sex, muscular development, or other physical conditions of the subject. In muscular or thin persons there are distinct prominences and depressions, while in fat subjects the surface is smooth and rounded.

The *skin* covering the anterior and inner part of the arm is without hair, thin and delicate, qualities first taken advantage of by Tagliacozzi in rhino-plastic operations. It is easily torn or abraded. The pressure of splints or other apparatus quickly raises the epidermis. Care must always be taken, therefore, that pressure be neither too great nor too long continued. On the back of the arm the skin is thick, rough, and with more or less hair. The skin is everywhere connected with the subjacent aponeurosis by very loose connective-tissue. It is therefore very mobile, and may be easily dissected up with the fingers in making a skin-flap, for which form of amputation it is peculiarly well adapted. It follows that blood and pus easily make their way between the skin and the aponeurosis in all directions. The arm has four distinct surfaces, anterior, posterior, external, and internal. The prominence of the *anterior surface* is very marked, especially in the muscular, and is composed of the biceps and brachialis anticus muscles. The brachialis anticus covers the lower half of the anterior surface of the humerus, while the belly of the biceps extends the whole distance from the lower border of the pectoralis major to the bend of the elbow. The biceps, overlapping the brachialis anticus in the middle of the arm, becomes narrowed as it approaches the elbow. The brachialis anticus becomes broader, so that just before its insertion into the coronoid process it presents a flat surface on either side of the biceps tendon.

The *posterior surface* is rounded and made prominent by the bellies of the triceps muscle, which, very distinct in muscular subjects, give no surface markings in others.

The *external surface* is flattened and corresponds to the interval between the muscles of the anterior and posterior parts of the arm. It is bounded above by the muscular part of the deltoid, converging to the middle of the outer part of the shaft of the humerus, where its insertion can be distinctly felt. Below, the external surface terminates in the supra-condyloid ridge of the humerus, covered by the origin of the supinator longus and the radial carpal extensors. The outer edge of the biceps is marked by a shallow groove, which terminates below at the bend of the elbow, and above, at the insertion of the deltoid,

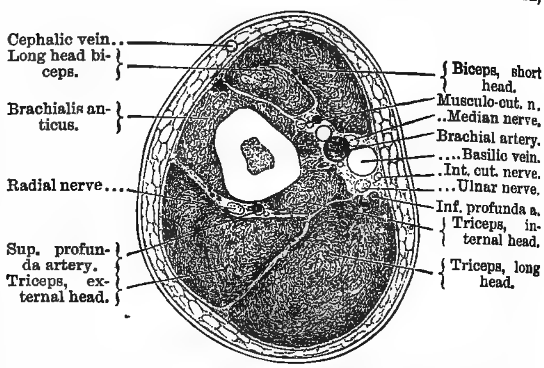

FIG. 236.—Transverse Section of Arm just below Insertion of Deltoid. (From Joessel; Lehrbuch der Topographisch-Chirurgischen Anatomie," Bonn, 1884.)

bifurcates like a letter Y, the two arms of which correspond to the anterior and posterior margins of that muscle. This is called the external bicipital groove, and it marks the course of the cephalic vein.

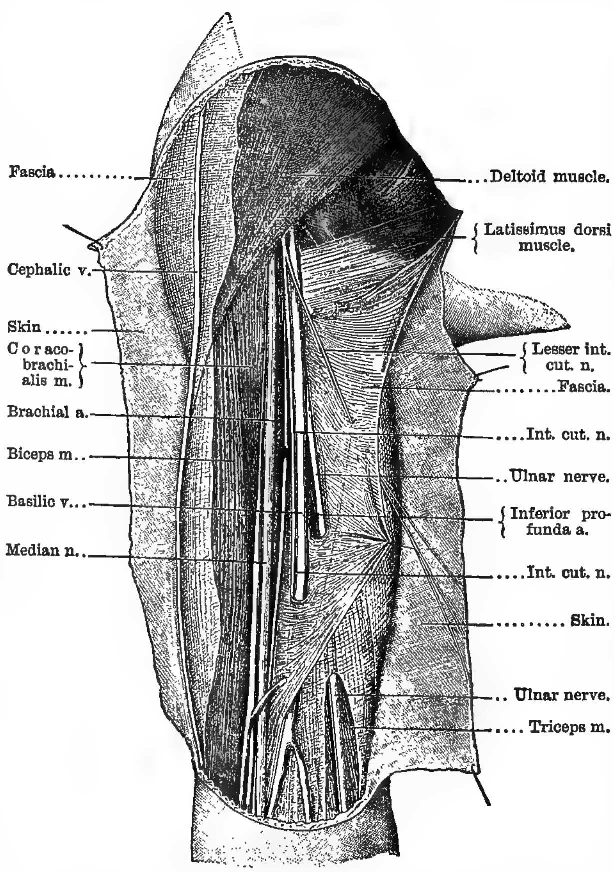

FIG. 237.—Dissection of the Arm, Anterior and Internal Surface. The skin and fasciæ have been turned back. (From Joessel.)

The *internal surface* of the arm is flattened, and marked by a groove extending from the axilla along the inner border of the coraco-brachialis and biceps muscles to the bend of the elbow. This depression, called the internal bicipital groove, indicates the course of the brachial artery, median, and internal cutaneous nerves, and in its upper part the positions of the ulnar and musculo-spiral nerves.

The brachial aponeurosis, thicker behind than in front, envelops the arm like a sleeve. It is pierced by the basilic vein and internal cutaneous nerve at about the middle of the inside of the arm, while the cephalic vein rests upon its external surface. Being strong but easily separated from subjacent parts, it may cause extensive infiltrations in all directions.

The arm is usually divided into an anterior and posterior compartment, by the attachment of a process of the brachial aponeurosis to the external and internal borders of the humerus. The external process — external intermuscular septum — passes to the bone between the bellies of the brachialis anticus and the triceps. The internal passes between the biceps and brachialis anticus in front, and the triceps behind (see Fig. 236). If a section is made through the arm, at a point betweeen the insertion of the deltoid and the origin of the supinator longus, it will be seen

that the biceps and brachialis anticus muscles, with most of the arteries, veins, and nerves, lie in front of the septum, and that the triceps muscle and one or two vessels and nerves lie behind. The anterior division of the arm contains the biceps and brachialis anticus muscles, insertion of deltoid and coraco-brachialis, brachial artery with its accompanying vein, median, part of ulnar, external and internal cutaneous nerves, basilic and cephalic veins.

The *biceps* forms the prominence of the anterior and inner surface. From its two points of origin, the coracoid process and upper margin of the glenoid cavity, it is first covered by the pectoralis major muscle, and becomes superficial at the beginning of the arm. It ends in a strong tendon inserted into the bicipital tuberosity of the radius. Its muscular portion is broad, convex from side to side, and from above downward. When cut it contracts strongly, partly because it has no attachment to the humerus, and partly because of its loose connective-tissue surroundings. On its outer side lies the cephalic vein. The brachial artery and median nerve run along its inner border.

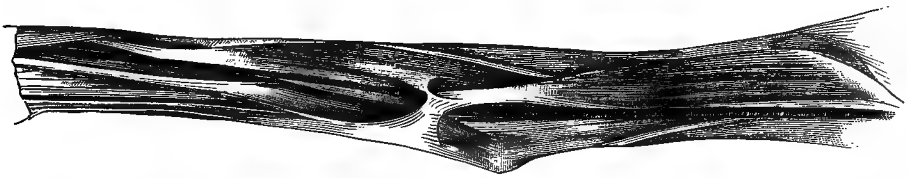

Fig. 238.—Superficial Dissection of the Upper and Forearm. The skin, fascia, and veins have been removed. The median nerve is seen to have an unusual relation to the brachial artery, passing from the outer side *behind* and to the inner side of that vessel. Thin subject, reduced to one-fifth normal size.*

Between it and the *brachialis anticus* is situated the musculo-cutaneous nerve. The brachialis anticus occupies the lower anterior half of the shaft of the humerus, gradually increasing in thickness as it approaches the elbow, where it is inserted into the coronoid process of the ulna. The cephalic vein and musculo-cutaneous nerve rest upon the outer and anterior surface of this muscle, while the brachial artery, median nerve, and basilic vein are upon its internal anterior aspect. When cut through, the brachialis anticus does not retract, on account of its extensive and intimate attachment to the humerus.

The *deltoid muscle* is inserted into the outer side of the middle of the shaft of the humerus. Just below this insertion the bone can be felt and examined. Everywhere else the shaft is surrounded by muscles, which make examination of the bone difficult. The skin over the insertion of the deltoid has been used for issues, vaccinations, etc., on account of the absence of large nerves and blood-vessels.

The insertion of the coraco-brachialis can be seen and felt on the inner side of the shaft opposite the insertion of the deltoid. Its inner border is the guide, first to the axillary and then to the brachial arteries.

Brachial Artery.—This artery lies in the groove on the inner side of the biceps. It is covered only by skin, fat, fascia, and more or less by the median nerve. It can be easily felt pulsating along its whole course. In its upper part it lies to the inner side of the humerus, and to be controlled must be compressed outward against that bone. The simplest object can be used to effect compression. By bringing the elbow firmly to the side and a little forward, the clothing is often enough to stop radial pulsation. By holding a book between the humerus and thorax with strong adduction, it may be wholly controlled.

Below the middle of the shaft the artery gradually inclines forward, and pressure to control it must therefore be directed backward. After exposing the inner side of the arm by removing skin, fascia, and fat, we find the brachial lying between the biceps and triceps in the greater part of its course. At the beginning it rests upon the long head of the triceps, with the musculo-spiral nerve and superior profunda artery intervening, and with the coraco-brachialis on its outer side. At the middle of the humerus it rests upon the tendon of insertion of the coraco-brachialis. In the lower part it rests on the brachialis anticus, and in contact with the inner head of the biceps (Fig. 239).

The *median nerve* is in front of the artery in the beginning of its course, and gradually inclines to the inner side, though not infrequently passing outside and behind to arrive there (see Fig. 238). Veins accompany the artery on each side, and at intervals communicate transversely (Fig. 244). The basilic vein, separated from the artery by the deep fascia at the lower half, pierces that structure and is on the inner side during the rest of its course to join the axillary. The musculo-spiral nerve is in contact with the artery at its upper end; the ulnar nerve accompanies it a short distance on the inner side, and gradually becomes separated from it to pierce the inter-muscular septum and reach the posterior surface of the internal condyle. The internal cutaneous nerve is placed to the inner side, about halfway down the arm, where it pierces the deep fascia and accompanies the basilic vein. The superior profunda branch of the brachial is given off in the first part of its course, and passes downward, backward, and outward with the musculo-spiral nerve. The inferior profunda is indicated by the line of the ulnar nerve, which it accompanies to the posterior part of the internal condyle. It leaves the brachial to join the nerve at about the middle of the shaft. The nutrient artery supplies the medullary cavity of the humerus and is given off at the middle of the shaft, directed downward. The anastomotica magna leaves the brachial about two inches above the elbow, and passes backward and inward to get behind the internal condyle.

The *median nerve* accompanies the brachial, lying first in front and then to the inner side. Its course is marked

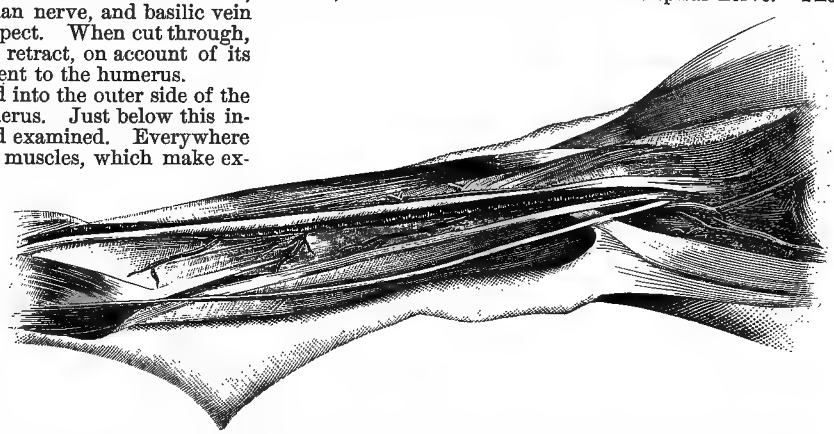

Fig. 239.—Dissection of Right Arm from Axilla to Elbow. The brachial artery is seen in relation to the median nerve, which first overlies and finally passes to the inner side of the artery. Both artery and nerve are seen to lie on the inner border, first of the coraco-brachialis muscle and then of the biceps, and upon the tendons of the latissimus dorsi and teres major muscles, then upon the triceps, and finally upon the brachialis anticus. The ulnar and internal cutaneous nerves are seen below, the ulnar passing behind the internal condyle, and the internal cutaneous over the pronator radii teres and flexor muscles arising from the internal condyle. The inferior profunda branch of the brachial is seen joining the ulnar nerve. Thin subject, two-fifths normal size.

* All the cuts used in this article, with the exception of Figs. 236, 237, 247, 248, 254, and 260, are copies of photographs taken by Dr. Mixter, from dissections made by the author.

by the same line as the brachial. It gives no branches in the arm.

The *ulnar nerve* is situated on the inner side of the brachial as far as the middle of the arm, where it passes behind the intermuscular septum into the posterior compartment, to get to the interval between the internal condyle and olecranon, accompanied by the inferior profunda artery.

The *musculo-cutaneous nerve* leaves the outer side of the axillary artery just before it becomes the brachial,

Fig. 240.—Dissection of the Anterior and Inner Side of Left Arm from Axilla to Elbow. The brachial artery is seen with the median nerve above it in the greater part of its course, but crossing to the inner side as it approaches the elbow. Just below the artery the internal cutaneous nerve is seen dividing into two branches. Below this is the basilic vein, and still lower the ulnar and lesser internal cutaneous nerves resting on the triceps. The skin and fascia have been removed. At the upper left hand are the insertions of the deltoid and coraco-brachialis muscles. Along the top is the biceps, and at the right upper corner the venæ comites of the brachial artery. Thin subject, two-fifths natural size.

and gradually inclines outward from the brachial to pierce the coraco-brachialis a short distance above its insertion. Thence it passes between the biceps and brachialis anticus, to appear in the lower part of the external groove.

The *internal cutaneous nerve* accompanies the brachial artery and basilic vein; leaving the former at the middle of the arm, and, piercing the deep investing fascia, it continues with the basilic vein to the bend of the elbow.

The *nerve of Wrisberg* is placed to the inner side of the brachial, as far as the middle of the arm, where it pierces the fascia, and is distributed to the skin on the inner and posterior side of the lower half of the arm.

In total paralysis of the brachial plexus, sensation is sometimes, if not always, retained in the skin between the axilla and the internal condyle, through the inosculation of the intercosto-humeral branch of the second intercostal nerve (Fig. 240).

The *posterior compartment* of the arm is composed entirely of the three bellies of the triceps muscle. The only other structures contained here are the musculo-spiral and ulnar nerves, with their accompanying arteries.

The *musculo-spiral* is in intimate relation with the brachial artery for a short distance, as it passes from the axilla obliquely outward to enter the musculo-spiral groove, accompanied by the superior profunda artery. Its oblique passage behind the humerus corresponds to the deltoid impression. Having pierced the intermuscular septum, it appears deep in the groove outside the biceps, covered by the supinator longus and extensors of radial carpus, to divide into the radial and posterior interosseous nerves. Its external cutaneous branches appear superficially in the outer bicipital sulcus.

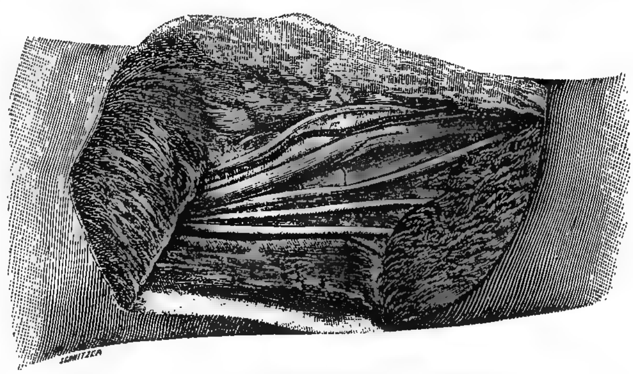

Fig. 241.—Dissection of the Musculo-spiral Nerve, etc. Right arm, thin subject. The triceps has been cut through, and its upper part turned back. The nerve is seen in the groove passing outward. Several branches pass from it into the substance of the triceps below. The middle of the cut corresponds to the insertion of the deltoid.

A longitudinal cut on the posterior aspect of the arm carried to the bone would divide this nerve. The use of crutches sometimes causes paralysis of it by pressure (crutch paralysis). It is possible for the nerve to become compressed between the fragments of a broken humerus, or to be involved in the callus. Tillaux speaks of a case in which he dissected this nerve from the callus which surrounded it, with complete recovery of its functions. From its close connections with the hard surface of the humerus, it may be injured by a blow as well as by pressure. For the same reason, in amputations it should be divided by a clean cut of the knife in the circular sweep by which the muscles are divided. Otherwise its fibres may be torn through with the saw.

The *triceps* occupies the whole posterior aspect of the arm. Its three bellies can be made out in muscular subjects, and its flattened tendon of insertion into the olecranon distinctly felt. Between its second and third heads the musculo-spiral nerve and superior profunda artery pass (Fig. 241).

Ligature of the Brachial.—The brachial artery may be tied in any part of its course, but the point of election is in the middle of the arm, where the median nerve passes in front from the outer to the inner side. The incision, about two inches in length, should be made in the line of the vessel from the junction of the middle and outer thirds of the axilla to the middle of the bend of the elbow. The forearm should be supinated. In the upper part of the arm (see Fig. 242) the median nerve lies to the outer side, separating the artery from the coraco-brachialis. The ulnar nerve lies to the inner side. The venæ comites, which are sometimes very large and communicate freely over the vessel, may complicate the operation somewhat. The artery, however, is not easily mistaken. In the *middle* of the arm the relations are similar. The biceps lies to the outer side, and the median nerve, in most cases, passes in front, while the ulnar is separated from the inner side of the vessel by a considerable interval. (See Fig. 243, in which the median lies on the outer side, and Fig. 238, in which that nerve passes behind the artery, as it not infrequently does.) The basilic vein may be in relation with the artery, but is generally separated from it so far as not to be seen (see Fig. 240). It must be borne in mind, that there are various anomalies of the brachial which may complicate the operation. The error to be guarded against is mistaking the median nerve for the artery, particularly when the nerve is directly in front and communicates to the finger the pulsations of the vessel beneath. Care should also be taken not to open the sheath of the biceps.

With regard to the effect of muscular contraction on the position of fragments in fractures of the humerus, there has been much difference of opinion among surgeons. At the present time the prevailing opinion seems

to be that fragments owe their position more to the direction and violence of the blow than to muscular contraction. In fractures of the lower extremity of the humerus, Velpeau remarks that displacement is apt to be slight, because the masses of muscle surrounding the bone rather tend to keep the fragments in place.

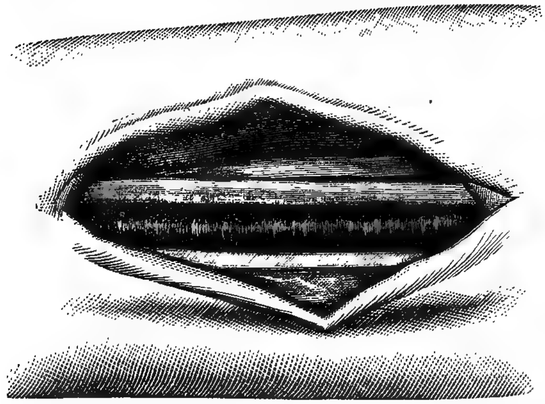

FIG. 242.—Dissection of Inner Side of Upper Arm; Relations of Right Brachial Artery near Axilla (axilla to right of incision, elbow to left). From top of incision to bottom are seen biceps, tendon of coraco-brachialis, median nerve, brachial artery, ulnar nerve, triceps muscle. (Slightly reduced in size.)

THE ELBOW.—The region of the elbow extends about two fingers'-breadth above and below the wrinkle in the skin made by the flexion of the forearm.

The anterior surface is flat. On each side are prominences formed by the muscles arising from the external and internal condyles of the humerus, which converge, forming a letter **V**. In the depression between these muscles the biceps tendon, brachial artery, and median nerve are situated. On each side the bony prominences of the external and internal condyle can be distinctly felt subcutaneously. In very fat persons these prominences may become depressions. Behind, the olecranon forms a

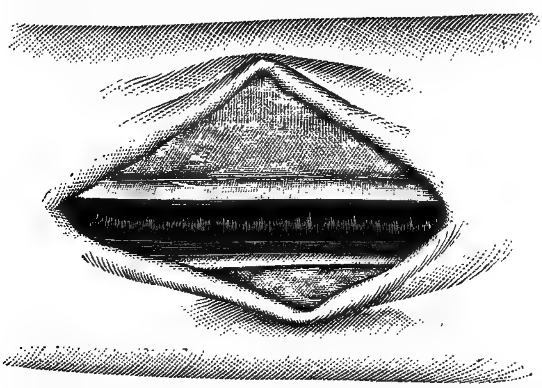

FIG. 243.—Relations of the Right Brachial Artery at Middle of Arm (axilla to right, elbow to left). In the incision the biceps muscle is seen at top (out side). Below its lower (inner) border is the median nerve, next brachial artery, then after a narrow interval the ulnar nerve resting on the triceps. Both biceps and triceps are represented covered with their fascia. The median is usually in front of artery at this point. (Slightly reduced.)

very prominent landmark, and in the depression between it and the extensor muscles the head of the radius in dislocations backward can always be felt, and its position clearly defined. Behind the internal condyle there is a depression which marks the course of the ulnar nerve. In effusions into the elbow-joint these depressions are obliterated or may become prominences, as the pressure of the fluid pushes the capsule of the joint backward on either side of the olecranon. Between them one may get fluctuation. Aspiration of the joint should be done on the outer side to avoid the ulnar nerve. The *skin* over the anterior aspect of the elbow is thin and translucent, and, except in cases where they are concealed by fat, the veins can be seen through it. Over the olecranon it may be very rough and thick. There exists in most cases, on flexion, a transverse furrow or wrinkle, which may disappear wholly on extension. This does not correspond to the joint, but is situated two to four centimetres (about an inch) above it, and is so variable in position as to be of no value as a landmark. From its delicacy the skin is easily abraded by splints. In normal extension it is slightly stretched, and in violent efforts at extension, as in the reduction of a chronic contraction, it is liable to be torn. The same thing may happen by pressure of the prominence of the humerus in backward dislocation of the radius and ulna.

The *superficial veins*, situated just beneath the skin, consist of three approaching the joint—radial, median, and ulnar—and two leaving it, the cephalic and basilic. The radial becomes the cephalic, and the ulnar the basilic; while the median, which ascends the arm between the radial and ulnar, bifurcates, sending a branch to both cephalic and basilic: the median cephalic and median basilic. The median basilic passes over the bicipital fascia and median and internal cutaneous nerves. Being separated from the brachial artery only by bicipital fascia, that vessel may easily be wounded when this vein is selected for venesection. It is in this way that arterio-venous aneurism may be formed. The median cephalic passes over the tendon of the biceps and rests upon the brachialis anticus.

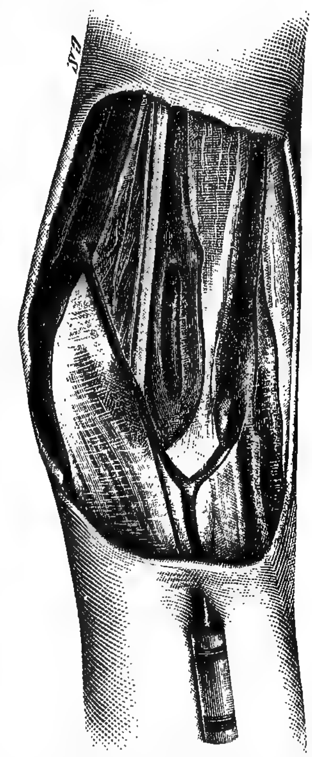

FIG. 244.—View of the Bend of Elbow of Left Arm. (Thin subject, two-thirds normal size.) Injecting pipe introduced into median vein through skin. The median cephalic vein, small in size, is seen passing upward and outward to form with radial the cephalic vein; median basilic upward and inward to form with ulnar the basilic vein. In the centre of incision, between biceps tendon and median nerve the brachial artery is seen, almost entirely concealed by its *venæ comites*. The internal cutaneous nerve lies just inside the median, and passes under the median basilic.

The *musculo-cutaneous* nerve appears on the outer side of the biceps, a short distance above the joint, resting on the brachialis anticus. Passing behind the median cephalic, it supplies the integument of the outer side (see Fig. 238).

The *internal cutaneous* passes behind, less frequently in front of, the median basilic. In the latter position it may be injured in venesection, causing neuralgia, etc. (It will be seen in Fig. 244 that the nerve passes behind the vein.)

The *bicipital fascia* leaves the tendon of the biceps and passes downward and inward to join the aponeurosis covering the muscles of the internal eminence, where it becomes continuous with the aponeurosis of the forearm. It crosses the brachial artery, protecting it to a certain extent. When the arm is flexed the finger can be hooked under the edge of the fascia (see Fig. 245).

The *brachial artery* passes obliquely downward from within outward, along the inner side of the biceps tendon to the middle of the bend of the elbow, where it divides into the radial and ulnar. The bicipital fascia is

in front, and the median nerve on its inner side, while it rests on the brachialis anticus.

The artery at this point is accompanied by veins (see Fig. 244) which communicate freely. These may be involved in a wound of the artery, which frequently occurs, and an aneurismal varix may result. In forced flexion pulsation may be entirely checked, and hæmorrhages from the vessels of the forearm may be controlled in this way. The same method may be used in the treatment of an aneurism or an aneurismal varix at the elbow, diminishing the flow of blood through the artery, and exerting direct pressure on the sac.

The *median nerve* is situated on the inner side of the artery, but gradually becomes separated from it to pass between the heads of the pronator radii teres.

The *biceps tendon* is situated on the outer side of the artery, and may be felt almost to its insertion into the bicipital tubercle of the radius. It is separated from the anterior part of the tubercle by a bursa, which may be the seat of an inflammation or the origin of a cyst. The biceps is a supinator of the forearm as well as a flexor, and its insertion should be saved if possible in excision of the joint. It is important to distinguish between the biceps tendon and the median nerve in operations upon the brachial. The tendon is broad, white, and glistening;

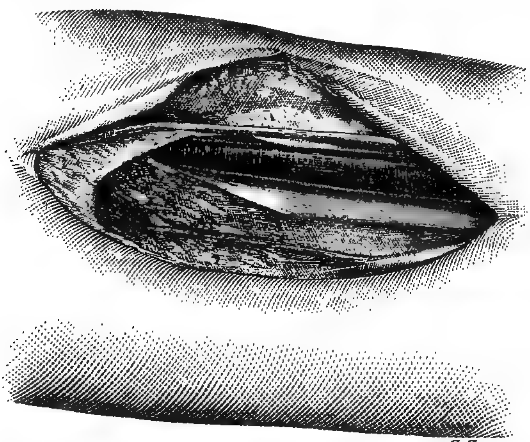

FIG. 245.—Dissection at Bend of Right Elbow. At extreme left of incision is the bicipital fascia as it blends with the aponeurosis covering muscles of internal condyle. At top of incision is fascia covering biceps. At the centre is seen the brachial artery lying above (to outside) median nerve. Below, the internal cutaneous nerve crosses belly of *pronator radii teres* muscle. All veins have been removed. (Thin subject, normal size.)

the nerve is smaller, more rounded, and yellow. If the former is met with, one must go to the inner side; if the latter, to the outer.

The brachialis anticus forms the floor of the space at the bend of the elbow. It is inserted into the coronoid process, and this insertion should be saved in excisions when possible. The radial nerve pierces the external intermuscular septum after leaving the musculo-spiral in its groove, and passes between the brachialis anticus and the supinator longus. It then lies behind the supinator longus. The ulnar nerve is situated in the groove between the olecranon and internal condyle. It has been known to pass in front of the condyle, or to be dislocated from its normal position. It is liable to injury, though somewhat protected by the prominences on either side. In excisions of the joint the nerve should never be seen, but turned back with the periosteum. The broad and thick tendon of the triceps can be felt at its insertion into the olecranon. This muscle is very powerful, and it is a question whether its violent and sudden contraction may not be the most important factor in the production of fracture of the olecranon, in falls upon the elbow. While, in excision of the joint, it is quite easy to save the insertion of muscles which flex the forearm, it becomes very difficult to do so with the triceps. It is best to save the tendon and its connection with the periosteum of the ulna by removing them all together. Very good power of extension follows this procedure.

Between the olecranon and the skin there is a bursa of considerable size, which is often the seat of an acute or chronic inflammation. An acute bursitis here may result in rupture of this sac, and extension of inflammation in all directions under the skin. It is not uncommon for pus starting at this point to dissect the skin, as far down as the wrist, from the aponeurosis which protects the deeper structures. Chronic inflammation of this bursa gives rise to a hygroma, often of considerable size, known as "miner's elbow."

Two to three centimetres above the internal condyle there is situated a lymphatic gland (epitrochlear) resting on the intermuscular septum. Sometimes there are two of these glands. It is often inflamed in wounds of the hand, particularly of the last three fingers. Sigmund attaches great importance to the enlargement of this gland in the diagnosis of syphilis, but his views are disputed by many. Inasmuch as the epitrochlear gland becomes involved sooner or later in the natural progress of malignant disease of the hand or forearm, it should always be carefully examined in such cases.

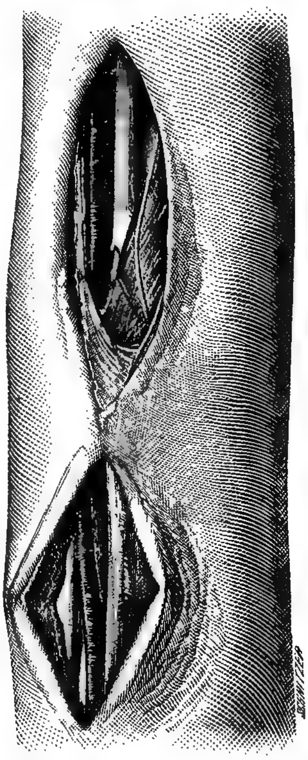

FIG. 246.—The upper incision shows the relations of the right brachial at bend of elbow. From outer side (left) to inner are bicipital fascia, brachial artery, median nerve, and pronator radii teres covered by internal cutaneous nerve. The lower incision shows relations of right radial artery in upper third of forearm. From left (outer side) to right are seen: supinator longus drawn to outside, radial nerve, radial artery resting on pronator radii teres, and flexor carpi radialis muscles. (Four-fifths normal. Thin subject.)

Ligature of the Brachial at the Bend of the Elbow.—An incision about two inches in length should be made along the inner border of the tendon of the biceps, beginning at the level of the internal condyle. The bicipital fascia, having been exposed by the first incision, should be divided upon a director, as it is sometimes very thin. The artery and its venæ comites will then be exposed. In some cases the presence of these veins conceals the artery and complicates the operation, as in Fig. 244, where but a small part is visible. The median nerve will be found to the inner side of the artery, sometimes separated a short distance from it. The needle should be passed from the inner side to avoid the nerve (see Figs. 245, 246, and 249. Figs. 245 and 246 are enlargements of the upper incision in Fig. 249). A high division, or other anomalies of the brachial, may complicate the operation.

The forearm extends from two fingers'-breadth below the elbow to the styloid processes of the radius and ulna. The shape of the forearm is conical, and markedly so in muscular individuals. This explains the difficulty of dissecting back a cuff of skin in amputations without dividing longitudinally. The forearm is flattened transversely, which shape facilitates amputation by antero-posterior flaps. The skin in front is smooth and thin, while behind it is thick and covered with hairs. It is more or less adherent to the muscular aponeurosis, and must be dissected

back in flap amputations. The ulna can be felt subcutaneously from the olecranon to the styloid process. By passing the finger rapidly along this surface any irregularity or deformity can be detected very readily, especially in supination. The radius is deeply placed among

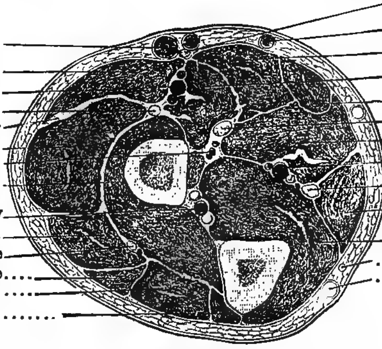

FIG. 247.—Transverse Section through Upper Part of Forearm. (From Joessel.)

muscles in its upper half, and only its head can be felt. In its lower half it gets nearer the surface, and in injuries at this point the condition of the bone can be made out with comparative ease.

When the arm is supinated two shallow longitudinal grooves can be seen on its anterior surface, particularly in thin people. The outer extends from the middle of the bend of the elbow to the styloid process of the radius, and corresponds to the course of the radial artery. The inner runs from the internal condyle along the edge of the flexor carpi ulnaris, ending at the outer side of the pisiform bone, and marks the course of the ulnar artery and nerve. The muscular masses which make up the lateral prominences near the elbow, comprise the muscles arising from the condyles, and their size varies with the individual. On the posterior surface of the forearm there is a marked depression between the extensor communis digitorum and the supinator longus, with the two radial extensors. Near the carpal extremity of the radius there is a slight prominence, formed by the extensors of the thumb crossing obliquely the supinator longus and radial extensors. Over this prominence is felt, better than anywhere else, the synovial friction or creaking which accompanies inflammation of the tendon sheaths (Teno-vaginitis crepitans).

Between the extensor communis digitorum and the muscles arising from the internal condyle, there is a very marked depression when the arm is supinated, and it is along this sulcus that the ulna is subcutaneous.

The muscles of the forearm are invested by a strong aponeurosis, which is continuous with that of the elbow above and the wrist below. Upon this, embedded in more or less fat, the ulnar, median, and radial veins rest, together with the terminal branches of the internal and musculo-cutaneous nerves. The internal cutaneous nerve supplies the skin on the inner side before and behind, and the musculo-cutaneous the anterior and outer side. In injuries to these nerves higher up, the ulnar and median nerves exert an influence in restoring sensibility to the skin through inosculations, which pierce the investing aponeurosis.

Posteriorly, on the outer side, the skin is supplied by the lower external cutaneous and radial branches of the musculo-spiral. The investing aponeurosis is very adherent to the subjacent muscles, some of their fibres arising from it, and is attached on either side to the radius and ulna by means of septa, which are inserted into those bones. The forearm is then divided into an anterior and posterior compartment, separated further by the interosseous membrane. The anterior compartment contains externally the supinator longus, extensores carpi radiales longior and brevior, and supinator brevis. The radial nerve is covered by the supinator longus in the upper part of the forearm, but emerges from between that muscle and the extensor carpi radialis longior in the lower and outer part, and is subcutaneous in the rest of its course. Just below the elbow, where the supinator longus meets the pronator radii teres, at the extremity of the **V**-shaped depression, the radial nerve is in relation with the radial artery on its outer side (Fig. 247).

The *posterior interosseous* nerve pierces the supinator brevis muscle about two to three centimetres (one inch) below the upper part of the head of the radius. In resecting the head of this bone, one must not forget the position of the nerve, because, if seriously injured, paralysis of the extensors will follow. The

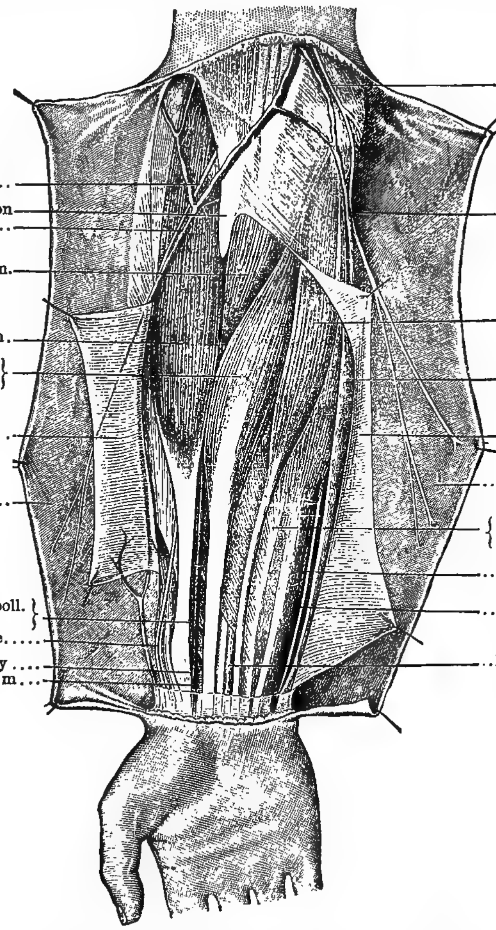

FIG. 248.—Superficial Dissection of Forearm. (From Joessel.)

relations of the important vessels and nerves of the anterior region of the forearm are best understood by dividing

the muscles into three layers. The first layer consists of the pronator radii teres, flexor carpi radialis, palmaris longus, and flexor carpi ulnaris muscles.

All these muscles arise from the internal condyle. The pronator radii teres is inserted into the outer side of the radius at about its middle. The other muscles are tendinous at the wrist and superficial, and between them the tendons of the middle layer may be seen. In amputations of the forearm it should not be forgotten that, if the bone is cut through below the insertion of the pronator radii teres, the power of pronating the stump is retained.

In the upper part of the forearm the radial artery, which is the direct continuation of the brachial, rests upon the supinator brevis and the insertion of the pronator radii teres (Fig. 246), and to the inner side of the supinator longus. In the rest of its course it is placed between the latter muscle and the flexor carpi radialis, often concealed above by the bellies of those muscles (Fig. 248), and is separated below from their tendons by a considerable interval. Though in relation with the radial nerve in the upper part of the forearm, as the artery approaches the wrist it is separated from that nerve by the tendon of the supinator longus, and has no important nerve in direct relation with it. This vessel is within the sheath of the pronator radii teres. For this reason it is insufficient to turn back the supinator longus when one wishes fully to expose the artery.

The flexor sublimis digitorum composes the second and middle layer of muscle. The deep layer is made up of the flexor profundus digitorum and the flexor longus pollicis. Between the middle and deep layer we find the median nerve, ulnar artery, and ulnar nerve.

The median nerve leaves the bend of the elbow behind the inner arm of the **V** and passes between the two heads of the pronator radii teres, crossing the ulnar artery at its origin, and separated from it by the deep slip of that muscle. It then passes straight to the wrist between the flexor profundus and sublimis digitorum, where it becomes superficial, appearing between the tendons of the flexor carpi radialis and the flexor sublimis digitorum, partly concealed by the palmaris longus, which is placed rather to its ulnar side. The median nerve supplies all the muscles of this group, except the inner half of the flexor profundus and the flexor carpi ulnaris. In violent muscular contraction, as in rowing, gymnastic exercises, etc., the nerve may be compressed and give rise to painful cramps. The median nerve is accompanied by a small artery, comes nervi mediani, which sometimes is very much enlarged; in such cases it passes under the annular ligament with the nerve and joins the superficial palmar arch. This may explain the recurrence of hæmorrhage from a wound in the palm after both ulnar and radial arteries have been tied (Holden).

The *ulnar artery*, larger than the radial, arising from the brachial at the bend of the elbow, opposite the inner border of the neck of the radius, inclines obliquely downward and inward under the pronator radii teres, flexor carpi radialis, palmaris longus, and flexor sublimis digitorum. It rests first upon the brachialis anticus, and then upon the flexor profundus digitorum. At about the middle of the forearm it is joined by the ulnar nerve in its passage from behind the internal condyle to the wrist. In the tendinous part of the forearm the artery becomes superficial, placed on, and sometimes under, the radial border of the flexor carpi ulnaris, with the inner tendon of the flexor sublimis digitorum on its outer side. The ulnar nerve is in intimate relation with the artery in the lower half of its course, and, situated on its ulnar side, is sometimes even entirely hidden by the tendon of the flexor carpi ulnaris. The ulnar nerve, leaving its groove behind the internal condyle, descends between the flexor sublimis and profundus digitorum, and joins the artery in the middle third of the forearm. Above, it is separated from the vessel by the elbow-joint and the muscles of the internal condyle. After joining the artery it is in very intimate relation with it. In the upper part of the forearm both artery and nerve are covered entirely by muscles. Lower down they are more superficial, and yet even there they are deeper than the radial. In tying the artery in amputations, care must be taken to separate it well from the nerve. The ulnar nerve supplies the inner half of the flexor profundus digitorum and the flexor carpi ulnaris. The anterior interosseous branch of the nerve is situated beneath the deep layers of muscle, and, with the anterior interosseous branch of the median, rests upon the interosseous membrane as far as the pronator quadratus muscle, in the substance of which it ends, while the artery pierces the membrane to gain the back part of the wrist.

The posterior compartment of the forearm consists of two layers of muscles, superficial and deep. The superficial layer comprises the extensor communis digitorum, the extensor minimi digiti, extensor carpi ulnaris, and anconeus. The deep layer consists of the three extensors of the thumb, extensor ossis metacarpi pollicis, extensor primi internodii pollicis, extensor secundi internodii pollicis, and the extensor indicis. These muscles are all supplied by the radial nerve. The posterior part of the forearm is remarkably free from arteries and nerves. The only artery is the posterior interosseous branch of the ulnar, and the only nerve is the posterior interosseous branch of the musculo-spiral. In paralysis of the musculo-spiral nerve the power of extension and supination is lost; of the median, pronation and the greater part of flexion; of the ulnar, a small part of flexion.

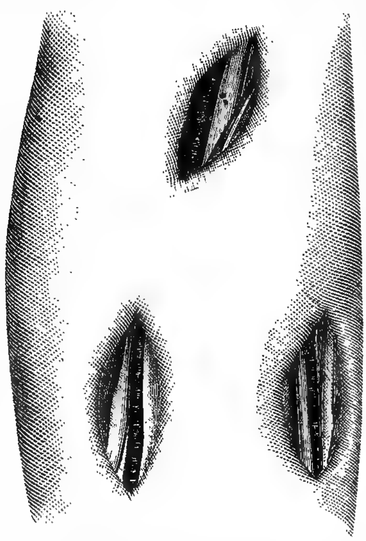

Fig. 249.—Right Arm. Ligature of brachial at bend of elbow, and radial and ulnar in upper third of forearm. (Muscular subject, one-third normal size.) For enlargements of these incisions see Figs. 245, 246, and 250.

The ulna is nearly straight, the radius is convex on its outer side. Both bones are in contact at each extremity, but are separated at the middle of the forearm by quite an interval. The width of this space varies, but is greatest in a position half-way between pronation and supination.

Ligature of radial in upper third of the forearm.—The line marking the course of the radial artery is drawn from the middle of the bend of the elbow to the styloid process of the radius, or base of the metacarpal bone of the thumb. An incision from two to two and a half inches in length should be made along this line to the space between the supinator longus and the pronator radii teres. In muscular subjects it will be necessary to turn back the supinator longus. The artery, with its two nerves, will be found in the sheath of the pronator, which will require to be opened. The radial nerve lying on the outer side makes it necessary to introduce the aneurism needle from without inwards (Fig. 249).

Ligature of Ulnar Artery in Forearm.—The course of the artery in the middle and lower third is marked by a line drawn from the internal condyle to the pisiform bone. An incision, two to three inches in length, should be made along this line, exposing the deep fascia at the septum which separates the flexor sublimis digitorum from the flexor carpi ulnaris. This fascia having been divided with the knife, the muscles can easily be separated with the handle of the scalpel. This must be done horizontally, and not from before backward. The ulnar nerve will first come into sight, and then the artery. The nerve is so constant in this relation that it may be said to be the guide to the artery. Care must be taken not to confound the median

with the ulnar nerve, which may happen if one goes through and not under the flexor sublimis (see Figs. 249 and 250).

The WRIST is situated between the forearm and hand, and, surgically speaking, extends about two fingers'-breadth above and below the radio-carpal joint. It may be divided into an anterior, posterior, and external region.

The skin of the anterior region, like that of the forearm, is thin and smooth, and marked with transverse folds, the lowest of which is the most distinct. This is situated over the neck of the os magnum, corresponding with the inter-carpal joint, two centimetres (three-fourths inch) below the articulation of the radio-carpal joint, and one and a half centimetre (one-half inch) above the metacarpo-carpal joint. The other folds are of little value as surgical guides.

A prominence made by the tendon of the palmaris longus can be seen distinctly in the middle of the anterior aspect of the wrist, separated from the tendon of the flexor carpi radialis by a narrow groove in which lies the median nerve. On the inner side, the insertion of the flexor carpi ulnaris into the pisiform bone can easily be made out, and deeply on its radial border the pulsation of the ulnar artery can be felt. Deeply placed between the last-named muscles are the tendons of the flexor sublimis digitorum.

On the radial side of the flexor carpi radialis, which, though larger, is less distinct than the tendon of the palmaris longus, the radial artery is situated, and may be compressed backward against the radius. These tendons are brought out more distinctly in flexion. The skin of this region is very adherent to the subjacent aponeurosis, and is dissected from it with difficulty in amputating by skin flaps.

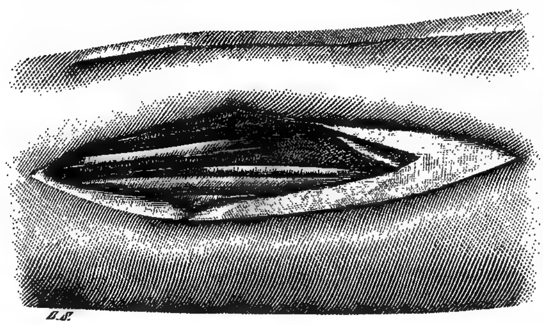

FIG. 250.—Relations of Right Ulnar Artery in Upper Part of Forearm. At upper side of incision flexor sublimis digitorum is turned back, and part of its tendinous fibres show from below. Ulnar artery is seen joined by ulnar nerve at middle of incision, resting on flexor profundus digitorum. Flexor carpi ulnaris is turned downward. (Two-thirds normal size.)

The structures of the wrist are covered by a strong aponeurosis, which is continuous with that of the forearm above, and with the annular ligament below. It serves to keep the tendons in place, and also offers strong resistance to the escape of pus when inflammation exists among the flexor tendons.

The relation of the large vessels and nerves of this region is of great surgical importance.

The tendons of all the long muscles of the anterior compartment of the forearm converge at the wrist, and with the arteries and nerves are arranged in a flattened bundle resting upon the pronator quadratus. The skin and aponeurosis having been removed, we find the following order of arrangement: Beginning with the radial side, the tendon of the supinator longus, radial artery, flexor carpi radialis, flexor longus pollicis, median nerve, palmaris longus, with tendons of flexor sublimis digitorum, ulnar artery, ulnar nerve, and flexor carpi ulnaris (Fig. 251). The tendons of the flexor profundus digitorum are concealed by the structures first enumerated, and their relations have no particular surgical interest, except in connection with the synovial bursæ to be described with the hand.

The *radial artery* at the wrist is very superficial, being covered only by skin and a layer of aponeurosis. It rests upon the radius behind, separated only by a thin layer of muscular fibres (*pronator quadratus*). The pulsation of this artery can be entirely stopped with slight pressure of the finger directed backward against the radius. From its superficial position the radial is easily wounded. When cut it should be tied or twisted at both ends, on account of the free anastomoses of the palm.

The artery is sometimes very tortuous and subject to atheromatous degeneration of its walls. Aneurisms are not uncommon, especially of traumatic origin.

At the styloid process the radial changes its direction, and passes outward and forward over that bone to gain the interval between the extensors of the thumb on the external side of the wrist. As it curves outward it gives off the superficialis volæ branch, which, with the ulnar forms the superficial palmar arch. Ordinarily this branch is quite small, but at times it is very much enlarged (see Fig. 259) and gives rise, in such case, to severe hæmorrhage when wounded.

The *median nerve* lies behind the tendon of the palmaris longus, and somewhat to its radial side. In its course from the forearm it gradually leaves its relation with the flexor profundus digitorum and becomes superficial, mingling with the tendons of the superficial flexor, from which one sometimes has difficulty in distinguishing it. Its difference in color, texture, and position, is generally sufficient for its recognition, but when its guide, the palmaris longus, is wanting or is abnormally placed, much confusion may arise.

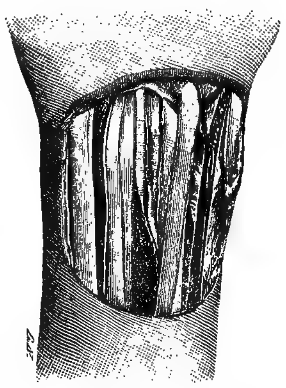

FIG. 251.—Anterior View of Right Wrist. (Thin subject, two-thirds normal size.) The skin and fascia have been removed. The structures are seen in the following order from right of incision to left (radial to ulnar side): Supinator longus tendons partly covered by aponeurosis, radial artery resting on radius, flexor carpi radialis, flexor longus pollicis, median nerve, tendons of flexor sublimis digitorum, ulnar artery, flexor carpi ulnaris. The ulnar nerve is concealed by the tendon in this subject. There is no palmaris longus present.

To expose the median nerve in the carpal region, the hand should be supinated, and a longitudinal cut of three centimetres (one inch) made on the ulnar border of the flexor carpi radialis. If the palmaris longus is present, the cut should be made in the groove between the two tendons. The fascia having been divided, the nerve will be found close to the inner border of the radial flexor, and a little deeper than it. The palmaris longus for the reasons given, is not so sure a guide to the nerve as is the flexor carpi radialis.

The occasional presence of an enlarged median artery should be borne in mind in seeking for the nerve.

Incisions deep into the wrist should be made on the ulnar border of the palmaris longus, to avoid the nerve.

The *ulnar artery* is more deeply placed than the radial. It is covered by skin, two layers of aponeurosis (the second separating the superficial and deep flexors), and is often partly concealed by the flexor carpi ulnaris. Its pulsations cannot be easily perceived by the finger, and there is more difficulty in exposing it. The ulnar continues on its straight course to the palm, lying to the radial side of the pisiform bone, resting on the annular ligament.

The *ulnar nerve* is placed to the inner side of the artery in the wrist. It is often wholly concealed by the flexor carpi radialis. Its relation is very constant, and it forms a valuable guide to the artery. Six to eight centimetres (two to three inches) above the carpal joint the ulnar gives off its posterior branch, which passes behind the flexor carpi ulnaris to supply part of the dorsum of the hand and fingers.

On the *external surface* of the wrist are found the extensors of the thumb and carpus, radial artery and nerve, and muscles of the thumb. The first two extensors, the extensor ossis metacarpi pollicis and extensor primi internodii pollicis, are placed together. They cross the two carpal extensors obliquely above the posterior annular ligament, and pass through grooves in the styloid process of the radius to their insertions into the thumb.

The tendon of the extensor secundi internodii pollicis crosses obliquely the carpal extensors below the annular ligament, and joins the extensor primi internodii pollicis at the base of the first phalanx. The interval between these tendons is a well-marked depression, when the thumb is strongly abducted and extended, known as the tabatière, or anatomist's snuff-box. In this depression, which corresponds to the scaphoid bone, can be felt the end of the metacarpal bone of the thumb and the radial artery, and the radial vein can be seen running over it subcutaneously (Fig. 252).

The *radial artery* in this region, winding around the styloid process of the radius, passing beneath the extensor tendons of the thumb, crosses obliquely the space between them, and descends between the first and second metacarpal bones to gain the palm. In its course beneath the tendons it is bound tightly to the carpus by a deep layer of fascia, which increases somewhat the difficulty of isolating the vessel.

The radial nerve becomes subcutaneous a short distance above the wrist, where it leaves the space between the

FIG. 252.—Dissection of the External Region of the Right Wrist. The radial artery is seen between the relaxed tendon of the flexor carpi radialis below, and the supinator longus on the outer (upper) side. It then passes beneath the first two extensors of the thumb and a small branch of the radial nerve, crosses the base of the thumb obliquely, and disappears under the tendon of extensor secundi internodii pollicis. (Thin subject, female, one-half normal size.)

supinator longus and extensor carpi radialis longior, and divides into two branches which supply the thumb and fingers, that supplying the thumb crossing the tabatière vertically.

The *posterior region* of the wrist is marked by the tendons of the remaining extensors of the fingers, the extensor carpi radialis longior and brevior, extensor indicis, extensor communis digitorum, and extensor minimi digiti. The dorsum is on the same plane as the posterior part of the forearm. In fractures of the radius this plane is often broken by a distinct elevation, which produces the familiar deformity known as the silver-fork fracture of the radius.

The styloid processes of the ulna and radius are very distinctly marked in the dorsum of the wrist, and their condition may be accurately ascertained in injuries of these bones (Fig. 253).

The skin of this region is thicker than that of the anterior, and is more or less hairy. It has folds produced by extension which are of little value as landmarks. It is easily dissected from the subjacent structures. The aponeurosis covering the external and posterior aspects of the wrist is continuous with that of the forearm above, and of the dorsum of the hand below, and is attached to the radius and ulna laterally. The ligamentum carpi commune dorsale is a reinforcement of the aponeurosis by fibres which run diagonally across from radius to ulna, from above downward. From the under surface of this fascia fibrous walls extend to the forearm and carpal bones, through which the tendon sheaths pass. These osteo-fibrous canals, lined with synovial membrane, allow free play to the tendons, and hold them close to the bone when the hand is in position of hyper-extension.

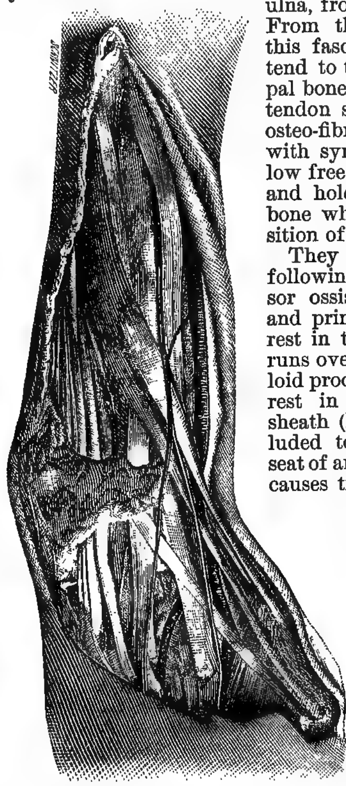

FIG. 253.—External and Posterior Region of Wrist, showing arrangement of tendons, artery, nerve, etc. The skin and fascia have been removed. (Four-fifths normal size.)

They are arranged in the following order: The extensor ossis metacarpi pollicis and primi internodii pollicis rest in the depression which runs over the side of the styloid process of the radius, and rest in the same synovial sheath (Fig. 254). This, alluded to above, is often the seat of an inflammation which causes transient pain, swelling, and friction (teno-vaginitis crepitans). In case the inflammation is the result of violence this crepitus may be mistaken for a sign of fracture.

To the ulnar side of the tendons last mentioned, we find those of the carpal extensors and the third extensor of the thumb. The first two are situated in separate grooves in the radius, and the third crosses them obliquely. These synovial sheaths generally communicate. Still further to the ulnar side is a deep depression for the extensor indicis and extensor communis digitorum. Between the bones is the tendon of the extensor minimi digiti, and in a groove on the ulna close to the styloid process is that of the extensor carpi ulnaris. All the tendons are accompanied by synovial sheaths for a varying distance from the posterior ligament (Fig. 254). If these sheaths are injected with mercury, small projections are seen through the dorsal ligament under the skin and subcutaneous fascia. It is from these projections, according to some surgeons, that ganglia are developed. Others think they more frequently start from the capsule of the joint, particularly that of the radio-carpal; for if this point be filled with air or mercury one notices, particularly on its dorsal aspect, little hernia-like projections of the joint capsules. A cyst formed in this manner would evidently be connected with the joint. The possibility of this condition of things existing should

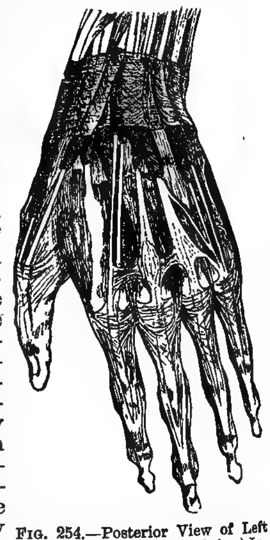

FIG. 254.—Posterior View of Left Wrist. (One-half normal size.) Injection of the synovial sheaths of the extensor tendons. (From Joessel.)

be borne in mind in cases in which the surgeon wishes to puncture or cut.

Ligature of the Radial in Anterior Part of the Wrist.—The course of this vessel is along a line drawn from the middle of the bend of the elbow to the metacarpal bone of the thumb. The incision should be made along this line, just above the annular ligament, about two inches in length, dividing the skin and subcutaneous tissues down to the aponeurosis.

The artery with its nerve will be found with the supinator longus on its outer, and the flexor carpi radialis on its inner, side. The vessel is then exposed by carefully incising the fascia covering it, and is separated from its venæ comites. There being no accompanying nerve, the needle may be passed from either side. In this operation the superficial position of the artery should be distinctly realized, for there is danger of wounding the artery longitudinally by the first incision.

The radial may be tied on the external aspect of the wrist in the interval between the extensor tendons of the thumb. A vertical cut four to five centimetres (one and a half inch) in length should be made from the styloid process of the radius to the base of the metacarpal bone of the thumb. The radial vein and the cutaneous branch of the radial nerve lie parallel to the

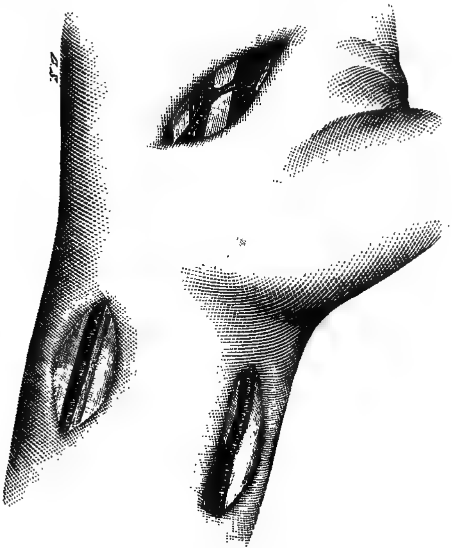

FIG. 255.—Ligature of the Ulnar, Radial, and Palmar Arch, Right Arm. Fig. 256 shows an enlargement of the two lower incisions in Fig. 255.

cut, and should be avoided if possible. The artery is often difficult to find on account of its deep position and aponeurotic coverings. It is always easier to tie on the anterior aspect of the wrist, so that this operation is of little practical use.

Ligature of the Ulnar at the Wrist.—An incision four to six centimetres (one and a half to two inches) in length should be made in the line of the artery along the radial border of the flexor carpi ulnaris, just above the annular ligament.

The muscular aponeurosis having been exposed and cut through, the artery and nerve will be found beneath the second layer of aponeurosis which covers the deep flexors. The artery and nerve are in such intimate relation that both are usually exposed. The nerve lying on the ulnar side of the vessel, the needle should be passed from within outward.

The HAND begins with the inferior fold of the wrist, and is divided surgically into a digital and metacarpal portion.

The metacarpal portion consists of an anterior and posterior surface, the palm and dorsum of the hand respectively.

The *palm* of the hand presents in its centre a well-marked depression, known as the hollow of the hand. Above, this is bounded by two eminences with a depression between them; an outer, formed by the muscles of the thumb, the thenar eminence, and an inner, formed by those of the little finger, the hypo-thenar eminence. Below the hollow, close upon the first phalanx of the four last fingers, there are longitudinal furrows, particularly well marked opposite the ring-finger, with rounded eminences between them which, if the fingers are fully extended, come plainly into view. These furrows indicate the course of the fibrous prolongations of the palmar fascia, which are firmly bound to the skin and draw it down. The rounded eminences projecting between the furrows consist of small masses of fat, under which lie the digital arteries and digital branches of the ulnar and median nerves.

The skin of the palm is marked by numerous furrows or wrinkles, three of which, arranged in the shape of an M, are of importance as surgical guides. The upper furrow runs from the interval between the thumb and hypothenar eminence, forward and outward to the base of the index finger, where it is joined by the second, which comes from the ulnar side less obliquely. Between the first and second furrows the superficial arch is situated, and the line of their union corresponds to the metacarpo-phalangeal joint of the index finger.

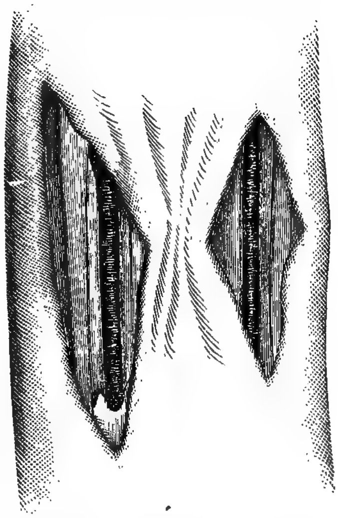

FIG. 256.—Relations of Radial and Ulnar Arteries at Wrist. The incision on left shows relations of ulnar artery. From left to right (ulnar to radial sides) are seen the tendons of the flexor carpi ulnaris, ulnar nerve, artery, tendons of flexor sublimis digitorum. The incision on right shows the radial artery resting on the right (radial) side of tendon of flexor carpi radialis. To the right of the artery is the tendon of the supinator longus separated by a narrow interval, through which the bony surface of the radius can be seen.

The inferior line starts from the eminence at the base of the index-finger and curves inward to the fifth. It marks the metacarpo-phalangeal joints of the last three fingers.

When the thumb is strongly abducted, the curve of its palmar surface, continued to the pisiform bone, would mark quite accurately the position of the superficial palmar arch (Fig. 258).

Longitudinal incisions through the furrows at the bases of the fingers, and below the middle transverse fold of the palm, will avoid the palmar arch and its branches, as well as the nerves of the fingers. The skin of the palm is thick and adherent. It is without hair and sebaceous glands, which explains the absence of furuncular inflammation on the palmar surface, while it is so common on the dorsum, where these appendages are found.

Between the epidermis and cutis vera of the palm abscesses often occur, which are sometimes explained by the presence of a mucous bursa in that place. When the epidermis is very thick and strong, pus may make its way under the true skin and form an abscess there. The communication between the two abscess cavities is generally by a small opening, from which arrangement the name of shirt-stud felon has been derived. The same thing may be produced by an abscess starting beneath the cutis vera, and later pushing up the epidermis through a small opening in the true skin.

The hollow of the hand is triangular in shape, with its base toward the fingers, and its apex between the thenar and hypo-thenar eminences.

The skin having been removed, a layer of fat is exposed, pierced by fibres which unite the skin firmly with the palmar fascia, and make the separation of these layers extremely difficult.

The *palmar fascia* is thick and strong, and consists of

FIG. 257.—Superficial Dissection of Palm. The skin, and as little fascia as possible, have been removed.

longitudinal fibres derived from the tendon of the palmaris longus, or, in cases where this muscle is absent, from the ante-brachial aponeurosis and the annular ligament. It is narrow and thick above, broad and thin below, where it divides into four processes, inserted into the sheaths and ligaments of the fingers and sides of the first phalanges. It is strengthened by transverse fibres attached to the second and fifth metacarpal bones.

Between the prolongations of the fascia to the fingers are the masses of fat spoken of above. In laboring men these are often the seat of an inflammation starting beneath the overlying thickened skin. Pus formed in this way should be relieved by early incision, for, if left to itself, it makes its way between the fingers to the dorsum of the hand, and sometimes involves the metacarpo-phalangeal joints.

From the borders of the palmar fascia is derived the thin aponeurotic covering of the muscles of the thenar and hypothenar eminences, continuous behind with the aponeurosis of the dorsum.

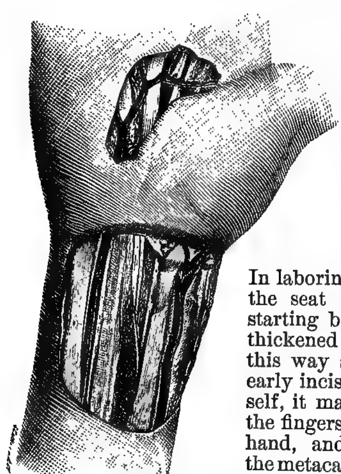

FIG. 258.—In this cut the wrist is a little more flexed than in Fig. 251. The ulnar nerve is not entirely concealed by the flexor carpi ulnaris, and the median is nearer the flexor carpi radialis. The palmaris longus is absent. The other relations are the same as in Fig. 251.

From the lateral borders also antero-posterior prolongations go to be attached to the third and fourth metacarpal bones, which, though delicate, offer sufficient resistance to prevent the extension of inflammation from the thumb or little finger to the important structures of the hollow of the hand.

The palmar fascia may become contracted, forming painful elevations under the skin, and gradually flexing the fingers so as to render them more or less useless. The failures which have followed division of the contracted fibres seem to justify the belief that other structures are instrumental in producing this deformity.

The *superficial palmar arch* is exposed on removing the palmar fascia. It is the direct continuation of the ulnar artery, and is completed by the superficial volar branch of the radial, which, usually of small size, may become much enlarged (Fig. 259). From the convexity of the arch the digital branches are given off, and proceed in a straight line to the interdigital folds, where each one divides to supply the adjacent sides of two fingers. The digital branches of the median and ulnar nerves are placed between the superficial arch and the flexor tendons. There is often a communicating branch between the two nerves in the palm. In their course to the fingers they accompany the digital arteries.

The median supplies the thumb, index, middle, and

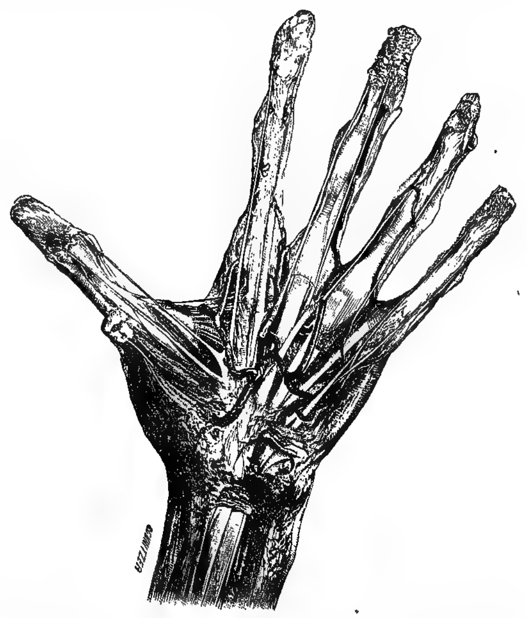

FIG. 259.—Dissection of Wrist and Hand. The skin and palmar fascia have been removed. The superficial arch is seen to be formed by a small ulnar artery and an enormously enlarged superficialis volæ branch from the radial.

radial side of ring-finger. The ulnar supplies the ulnar side of ring-finger and both sides of little finger.

Longitudinal incisions made over the metacarpal bones in the line of the middle of the finger will avoid both arteries and nerves.

The superficial and deep flexor tendons, emerging from the carpal arch, diverge to their respective fingers, where they both enter the same tendon sheath opposite the heads of the metacarpal bones.

To the deep tendons are attached the lumbricales muscles, which, inserted into the extensors on the dorsum of the fingers, flex the first phalanx and extend the two others. In paralysis of the extensors, therefore, the power of extending the terminal phalanges is not lost.

The flexor tendons are enveloped in a common sheath, which, though extending above the annular ligament, is mostly situated in the hollow of the hand. Another quite extensive sheath accompanies the flexor longus pollicis into the wrist. The tendon of the flexor carpi radialis has a third and smaller one, which is of little significance beyond its being occasionally the origin of a ganglion.

The larger sheath covering the common flexors (ulnar bursa) begins about two centimetres (two-thirds inch) above the annular ligament, where it is in contact with the ulnar nerve. Passing under the ligament, it is placed upon the inferior extremity of the radius and deep ligament of the carpus, to which it is firmly united, and beneath the tendons. Below the ligament it inclines obliquely to the ulnar side, entirely surrounding the tendons of the fourth and fifth fingers, and accompanying but a short distance those of the second and third. The special sheath of the fifth finger is almost always connected with the large flexor bursa, which explains the clinical fact that felons of this finger may be followed by extension of the disease into the thumb and forearm.

The sheath of the flexor longus pollicis is continued from the wrist, under the annular ligament, to the terminal phalanx. In many cases there is direct communication between this sheath and that of the flexors of the fingers, which explains the extension of thecal inflammation from the thumb to the palm, or even to the little finger.

Acute inflammation of these synovial sheaths is a very severe affection, and may be followed by grave results. From what has been said it is evident that a thecal inflammation starting in the thumb or little finger, from whatever cause, is more likely to extend into the palm and wrist than one beginning in the index-, middle-, or ring-fingers. In cases where the special sheath of the little finger communicates with the palm, pus may make its way there and into the wrist, where it may easily break through the thin walls of the bursa and dissect its way up the forearm with great rapidity, producing most serious results. The same progress may be seen in inflammation of the sheath of the flexor longus pollicis.

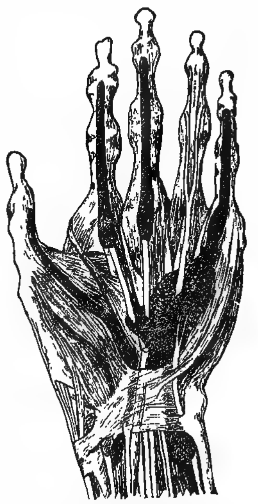

FIG. 260.—Showing the synovial sheaths of the flexor tendons injected. That of the little finger is seen to connect with the large palmar bursa extending under the annular ligament into the wrist. The flexor longus pollicis is accompanied to the wrist by a synovial sheath of its own. (From Joessel: one-half normal size.)

The median nerve passes under the annular ligament between the synovial sheath of the flexor longus pollicis and that of the flexores sublimis and profundus digitorum.

The ulnar nerve is also in contact with the inner bursa before it crosses the annular ligament. This proximity explains in part the existence of severe pain when these sheaths are inflamed and distended.

It is not uncommon in the palm to see a large cyst connected with the sheath of the flexors, corresponding in its general shape and outline to that of the bursa.

By pressure exerted above the wrist, and then over the palm, the fluid of this cyst may be tilted backward and forward with a peculiar friction sound, caused by the pressure of large numbers of small whitish bodies resembling rice. With strict antiseptic precautions after Lister's method, such a cyst may be emptied without serious results following the opening of the tendon sheaths. In all cases of inflammation of the palm free incisions should be made early, even before the presence of pus can be demonstrated by fluctuation, in order to prevent not only serious injury to the structures of the palm, but also the extension of the disease beneath the annular ligament into the forearm. The deepest layer of the palm consists of the interosseous muscles, with the deep palmar arch, and deep branch of the ulnar nerve.

The *deep arch*, smaller than the superficial, is the continuation of the radial, anastomosing with the deep branch of the ulnar. It is situated about one and a half centimetre (one-half inch) higher up than the superficial arch, and is so deeply placed as to be of little surgical importance in ordinary operations upon the palm.

It should be borne in mind that it may be wounded from the back of the hand, and that it may be very much enlarged, supplying the digital arteries usually derived from the superficial arch.

In the subject from which Fig. 261 was taken the deep arch was enormously enlarged and gave off the digital branches. In wounds of the large arteries of the palm it becomes a serious question what is the best course to pursue. A ligature, to be effectual, must be applied to both ends of the severed vessel; but this cannot be done without exposing the deep structures. If we tie the radial and ulnar at the wrist, we have communication with the palm through the anterior and posterior interosseous arteries and the carpal arches. Ligation of the brachial at the bend of the elbow or middle of the arm is followed by very free collateral circulation through the anastomoses about the elbow-joint.

When the cut is clean and of uncertain direction and depth, it is better to apply direct compression over the wound, and, if necessary, partial compression of the large vessels of the forearm or arm, than to expose the deep structures of the hand in the application of a ligature. This is generally successful, but if it fails it is then necessary to open the wound and tie the vessel at both ends.

FIG. 261.—Deep Dissection of the Anterior Surface of Hand. The flexor tendons have all been cut, but the nerves are left. The distribution of the nerves to the fingers is shown, and the deep branch of the ulnar entering the adductor and flexor brevis pollicis. In this subject the digital arteries were given off by the deep palmar arch, instead of by the superficial. (One-half normal size.)

The deep branch of the ulnar nerve is given off just below the pisiform bone, and passes downward and outward, with the deep communicating branch of the ulnar artery, between the flexor brevis minimi digiti and abductor minimi digiti. It supplies the interosseous muscles, the two inner lumbricales, the abductor, and the inner head of the flexor brevis pollicis.

In paralysis of the ulnar nerve the first phalanx is extended, but the two terminals are flexed; inasmuch as, like the lumbricales, the interosseous muscles extend the former and flex the latter (Tillaux).

The thenar eminence, covered by thin, fine, non-adherent skin, is made up of the short muscles of the thumb, the abductor, opponens, flexor brevis, and adductor pollicis. It is covered by a thin aponeurosis derived from the palmar fascia, and is cut off from the palm, as already

mentioned, by a layer of fascia attached to the third metacarpal bone.

The ball of the thumb is traversed in part by the superficialis volæ branch of the radial (Fig. 259).

Behind, the adductor pollicis is pierced by the radial artery in its course from the external region of the wrist to the deep palmar arch. The abductor, opponens, and outer head of flexor brevis pollicis are supplied by the median nerve, all the rest by the ulnar.

The hollow of the palm is bounded on its ulnar side by the hypo-thenar eminence, which is composed of the short muscles of the little finger—the abductor, opponens, and flexor brevis minimi digiti. This is covered by a thin aponeurosis, like the thenar region, and is shut off from the palm by a fascia attached to the fourth metacarpal bone. The skin is thick and often indurated.

The ulnar artery and nerve cross this eminence at the ulnar side of the unciform process, and supply the muscles of the little finger, and the skin covering them.

Dorsum of the Hand.—The skin is thin, elastic, and loosely adherent. It is covered with hairs and sebaceous glands, and is therefore very liable to furuncular inflammation. The subcutaneous connective-tissue being very loose, this region is frequently the seat of œdema, especially when the return of blood through the superficial veins is retarded by the pressure of bandages, splints, or other apparatus. The radial and ulnar nerves supply the skin of the dorsum—the radial supplying the thumb, index-finger, and half of the middle finger, and the ulnar supplying the rest. There is usually very free inosculation between these two nerves.

The tendons of the extensors of the fingers are flattened and bound down to the metacarpal bones. They are united by transverse fibres, which are particularly well marked and strong on either side of the tendon of the ring-finger. The result of this arrangement is that the three inner fingers are associated in their movement, and the ring-finger cannot be extended without also moving the others. These fibres have been divided subcutaneously, the operation resulting in greater freedom of the ring-finger.

The digital part of the hand consists of the five fingers, known as the thumb, index-, middle-, ring-, and little-fingers. Their number may be increased or diminished. When supernumerary fingers exist which are unsightly or interfere with the others, they should be amputated. They are sometimes provided with bones, joints, and tendons, and sometimes are composed only of soft parts united to the rest of the hand by a small pedicle. The thumb may be double or bifid. The fingers also vary in size and length. They may be curved from side to side, or antero-posteriorly, from deformity of the phalanges. Finally, they may be webbed by the extension of the interdigital commissures toward the finger-tips.

On the palmar surface of the fingers are seen three distinct folds, especially well marked in flexion. The first fold is twelve to fifteen millimetres (one-half inch) below the metacarpo-phalangeal joint, and may be used as a landmark in disarticulating this joint from the palmar surface. The second fold consists of two furrows, the one nearest the palm lying directly over the joint between the first and second phalanges. The third fold is situated between the second and third phalanges, and lies two and a half millimetres ($\frac{1}{10}$ to $\frac{1}{12}$ inch) above the joint. The second and third folds may be used as landmarks in disarticulating at the second and third joints. The thumb has three folds, although there are but two phalanges. The upper and lower correspond to the first and second joints respectively, while the middle one is opposite the centre of the first phalanx.

The palmar aspect of the fingers is composed of skin, fat, tendon-sheaths, tendons, and bone. The skin is dense and thick, like that of the palm, and is firmly attached to the underlying tissues. At the tips of the fingers it is abundantly supplied with tactile corpuscles and nerve-filaments.

Between the skin and tendon-sheaths, and attached to both, are collections of fat, arranged in three prominences on the palmar surface and separated by the transverse furrows. They are often covered by indurations from the pressure which they support. The tendon-sheaths of the fingers begin at the metacarpo-phalangeal joint, and end just short of the last phalanx, so that in amputation of the last joint they are not injured. The sheath of the tendon of the flexor longus pollicis, on the contrary, accompanies the tendon down to the last joint of the thumb, and is consequently opened in amputations of the terminal phalanx. The tendons glide through their sheaths with the greatest freedom, and when cut retract so far that it is almost impossible to suture the divided ends.

In the ligamenta vaginalia opposite the joints are often seen hernia-like projections of the synovial sheath, through small openings, especially when the sheath has been injected with mercury. In serous effusion and inflammation these little pouches form easily recognizable projections.

In chronic contraction of the fingers tenotomy of the flexor tendons is successful, unless flexion is prevented by permanent changes in the joint.

Destruction of the flexor tendons will be followed by permanent extension of the fingers, just as destruction of the extensors results in permanent flexion.

By a *felon* is understood a phlegmonous inflammation of the fingers, which may start in the adipose tissue beneath the skin, or in the network of lymph capillaries of the terminal phalanx. It may be limited to the subcutaneous cellular tissue, or it may break into the tendon-sheaths, and very rarely it may extend even to the bones. If the tendon-sheaths become involved, inflammation of the palm may follow, especially in tendons of the thumb and little finger, in the manner already spoken of. The skin on the posterior surface of the fingers, particularly of the first and second phalanges, is hairy, with numerous sebaceous glands, in which small furuncles may develop as on the dorsum of the hand.

The joints of the fingers lie very near the surface, and are generally opened from the dorsum. In such cases the flap is taken from the palmar surface. Situated in a fold of the terminal phalanx, the nail varies somewhat in shape in different people, and special types are met with which are said to be characteristic of certain diseases. Thus the clubbed fingers, in which the nails are bent and the terminal phalanges enlarged, are often seen in diseases where the circulation is retarded or the blood imperfectly aerated.

The nail is often the seat of an inflammation more or less severe, which may affect any of the soft parts around it, or may entirely destroy the matrix and give rise to great deformity (onychia, paronychia).

The arterial supply of the fingers is derived generally from the superficial palmar arch, the branches of which bifurcate opposite the digital folds. The thumb is supplied by the radial. The digital arteries proceed to the terminal phalanx, lying on each side of the flexor tendons. They anastomose freely from side to side, and end at the pulp in a small arch from which minute branches diverge to the very tips of the fingers. This abundant arterial supply to the fingers explains why one is able in many cases to secure a primary union even after complete separation of the ends of the fingers.

The nerves of the fingers—four in number, two on the palmar and two on the dorsal surface—are derived from the ulnar, radial, and median in the manner already referred to. They inosculate freely, both laterally and also from the palm to the dorsum.

Some anatomists maintain that the dorsal nerves terminate opposite the first joint, and that the last two phalanges are entirely supplied by the palmar nerves. If this view is correct, sensation will be retained on the backs of the fingers when the nerves of the dorsum are divided.

In avulsion of the finger by extreme violence, both the tendons, flexor and extensor, may be drawn out of the forearm,

Injuries to the Nerves of the Arm, Etc.—In paralysis of the musculo-spiral nerve the power of extension is lost, except that of the last two joints of the fingers.

which are extended by the lumbricales and interosseii. Supination is only possible through the biceps. It is impossible to extend the forearm, and the hand hangs flexed and limp (wrist-drop). Sensibility is lost over the skin supplied by the nerve.

Paralysis of the Median Nerve.—Through paralysis of the flexor sublimis digitorum, flexion of the second phalanges of all the fingers is lost; through that of the outer half of the profundus it is rendered impossible to flex the last joint of the middle- and index-fingers. A certain amount of flexion of the first, and extension of the second and third phalanges, is still possible through the interosseii. Pronation is lost, and flexion of the wrist accomplished only by the flexor carpi ulnaris. Sensation is lost over the skin supplied by the nerves already described.

In paralysis of the ulnar nerve, flexion of the ring- and little-fingers is greatly impaired, through loss of contractile power of the flexor carpi ulnaris, and inner half of the flexor profundus digitorum. At the same time all the muscles of the hand are paralyzed, except the three outer muscles of the thumb, and two radial lumbricales. The fingers cannot be separated or abducted, and the thumb cannot be adducted. Sensation is lost in the little-finger and in half of the ring-finger.

Sensation returns very quickly to the parts supplied by these nerves, even when the main trunks have been completely divided. This is explained by the numerous inosculations and by the interlacing of fibres between these nerves in different parts of the arm.

AUTHORITIES.

Tillaux, Joessel, Quain, Treves, Holden, Heath.

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ARM, DISEASES AND INJURIES OF.

DISEASES.

ABSCESS.—Abscesses of the upper extremity may occur at almost any point. The two most serious situations are the palm of the hand and the axilla.

Palmar Abscess.—Deep-seated abscess of the palm of the hand occurs quite often, and is of a pretty serious nature, owing to the pain and complications to which it gives rise. The cause is generally a lacerated wound, a contusion, or other injury. The inflammation is situated in the palmar aponeurosis, in the subaponeurotic tissue, and in the sheaths of the tendons. It frequently spreads so as to involve a large extent of tissue. The symptoms are those usually manifested in inflammation, namely, pain, heat, redness, and swelling. The constitutional symptoms are generally well marked. *Treatment.*—Blood must be taken locally, the hand must be kept elevated and covered with compresses wet with the Lotio Plumbi et Opii. Suppuration must be hastened by poulticing, and pus must be promptly evacuated. The bowels must be kept open and antifebrile remedies given. The sequelæ are necrosis, ankylosis, and contraction of tendons. There is great danger in this affection of a general cellulitis.

Axillary Abscess.—This may be either acute or chronic. In the acute form the pus may be confined to the connective-tissue, or it may spread in all directions, as beneath the scapula, beneath the pectoral muscles, into the anterior mediastinum, or into the neck. The usual signs of abscess will be present. *Treatment.*—This consists in making a free outlet for the pus; but in making the incision great care must be taken not to wound the axillary vessels, the best plan being to incise the skin and then divide the remaining tissues, layer by layer, on a director. The chronic form occurs especially in young, strumous subjects. The treatment is the same, with the addition that sinuses are frequently found which require special attention.

ADENITIS.—Inflammation and enlargement of the glands in the axilla present no special features, except in connection with cancerous affections, which will be treated of under Tumors.

ATROPHY, MUSCULAR.—Atrophy of muscles in the upper extremity may occur from a variety of causes. A very frequent cause is non-use, as in diseases of joints, or in injuries requiring long periods of rest. The cause may be central, however, as in infantile paralysis. Muscles may undergo degeneration—granular, fatty, or waxy—after rheumatism, lead-poisoning, syphilis, alcoholism, or chronic spasm, as in scrivener's palsy.

Perhaps the most curious form of degeneration is what is known as "progressive muscular atrophy," or "wasting palsy." This disease is generally very slow in its progress. The degeneration may be irregular, some of the fibres remaining intact. In some instances the degeneration may be simple, in others there may be fatty or granular changes. The consistence may be increased, owing to an increase of the connective-tissue. The muscular fibre may be yellow or colorless. The affection begins generally in the upper right extremity, passing from the hand to the shoulder, and then involving the muscles of the other limbs and the trunk.

It commences with loss of power, which gradually increases; there may be cramps, twitchings, or fibrillary tremors; occasionally there is pain, or some cutaneous anæsthesia. The disease is of central origin, and may be brought on by muscular exertion, exposure, syphilis, and injuries of the spine (Bryant). *Treatment.*—This must be directed toward the exciting cause. Tonics are indicated; arsenic has been used with success; galvanism must be applied to the affected muscles.

Degeneration of muscles, with apparent hypertrophy, known as "Duchenne's paralysis," occurs more especially in the lower extremities. It is most frequent in childhood.

ANÆSTHESIA of the upper extremity may result from wounds of the peripheral nerves, from pressure on the nerves by tumors, or from temporary pressure, as on the ulnar nerve at the elbow. The anæsthesia may be partial or complete; it may be accompanied by tingling sensations ("pins and needles,") formication, and numbness. The condition is apt to be accompanied by vaso-motor spasm, the effect of which is seen in the unnatural whiteness of the skin. The sensations are often presented as hot objects producing the sensation of cold, and *vice versa;* the temperature of the part is always lowered. The affection is frequently seen after sleeping with the arm in an unnatural position, as under the body or hanging over the back of a chair. The trouble is confined to the peripheral distribution of the nerve affected. *Treatment.*—The cause must if possible be removed. The electric current, applied by means of the "faradic brush," is of great value in this affection (Hammond). Hyperæsthesia occurs in several affections, more especially is it one of the phenomena in neuralgia.

ANKYLOSIS.—Ankylosis of the fingers and thumb may be caused by traumatism, syphilis, or any cause which results in an inflammation of a phalangeal or metacarpo-phalangeal articulation (Gross). The treatment must be "sorbefacient, with passive motion," friction with mercurial ointment, and any tendency of the part to return to its former position must be checked by means of a splint and roller-bandage. Persons whose occupation renders them especially liable to permanent flexions of the fingers, as tailors, shoemakers, and many others, should guard against them by proper exercise of the fingers, and the application of a splint or other apparatus at night.

(For Ankylosis of the other joints of the upper extremity, see the article on Diseases of Joints.)

ANEURISM.—Aneurisms of the upper extremity are discussed in the article on Aneurism.

BURSITIS.—The bursa over the olecranon process frequently undergoes a chronic enlargement, due to an inflammation of, and an effusion into, the tissues; this is sometimes known as "miner's elbow." The same enlargement occurs over the acromion process in men who carry heavy articles, as timber, in this position (Bryant). The cause in most instances seems to be "pressure," although this is not always the case, as such enlarged bursæ are sometimes found over the knuckle from no such cause. *Treatment.*—This consists in the removal of pressure and the application of blisters, or the cyst may be tapped and

kept from reforming by tight strapping; excision may be performed, or suppuration set up by means of a seton. In some cases a cure has been effected by injecting twenty drops of tinc. iodin.. co. in a drachm of water. When loose bodies exist in a bursa, they may be removed by means of a free incision through its walls.

In inflammation of the deep bursa beneath the deltoid muscle, there may be pain, crepitation, and such swelling as to simulate disease of the shoulder-joint. This form must be dealt with cautiously, as it frequently communicates with the shoulder-joint. The best treatment is absolute rest of the arm and counter-irritation by blisters. When pouches exist, they may be opened.

Ganglion.—The swelling of a bursa connected with the sheath of a tendon is called a "ganglion." This may be either localized or diffused. The localized form may be found connected with the flexor tendons, but it is most common on the dorsal aspect of the wrist. It is a cystic degeneration in the finger-like processes of the synovial membrane. The cause of this affection is almost always a strain. The swelling may be very hard, fluctuating, or soft; if large, it may be translucent; it is generally painful; occasionally it occurs in the palm of the hand, at the heads of the metacarpal bones, and in this location it is extremely painful. In the diffused (or compound) form the swelling will be deep-seated and irregular along the course of the tendons; sometimes all the flexor tendons will be involved, and the swelling will occupy the whole palm of the hand, and it may extend up the forearm. In these latter cases the "melon-seed" or "rice-like" bodies are usually found. *Treatment.*—The localized form may be treated when first found by applying a blister, and securing rest by means of a splint; if of long standing, however, the cyst must be punctured, or ruptured, the fluid squeezed out, and firm pressure made by a pad and strapping. The diffused form requires more serious treatment: rest must be secured for a few days by means of a splint, and an incision is then made in the affected sheaths free enough to allow the fluid to drain away. After the operation the splint should be kept on; movement of the fingers being allowed after a few days.

Cellulitis and Erysipelas of the upper extremity are discussed under the heads of Diseases of the Cellular Tissue and Erysipelas.

Caries and Necrosis of the bones of the upper extremity are discussed under the heads of Osteitis and Necrosis.

Contractions.—Dupuytren's contraction is a contraction of the fascia of the palm of the hand and of the little finger which results in a chronic flexion, more or less complete, of the finger; it occasionally involves the ring-finger. It is said to occur more frequently in gouty or rheumatic subjects. By some it has been thought to be due to the absorption of the deposit of fat which exists in the connective-tissue of the palmar fascia, this absorption being followed by inflammation. The *treatment* consists in making an incision at the palmar surface of the base of the fingers, which will divide the connecting prolongations of the palmar fascia; the finger is then straightened out and bandaged to a splint applied to the back of the fingers and hand. Passive motion of the finger should be made every day, the treatment being kept up for three or four weeks.

Any tendon may become contracted from inflammatory action, and require treatment which would be, of course, tenotomy.

Contraction of the long head of the biceps muscle may occur, and more or less prevent extension, thus necessitating tenotomy.

Gangrene.—Gangrene of the fingers and hand most frequently results from frost-bite; it has occasionally been caused by too tight bandaging, and particularly by plaster-of-Paris bandages having been too snugly applied. Gangrene from disease seems to be very rare in the upper extremity. The treatment of gangrene presents no special features in this region: bandages, and especially plaster bandages, should be frequently examined to ascertain whether they are sufficiently loose.

Joint-Diseases.—Joint-diseases of the upper extremity are treated under the general head of Joint-Diseases.

Lymphangitis.—Inflammation of the lymphatics frequently occurs in the upper extremity from poisoned wounds, or dissection wounds, or from wounds received by butchers while cutting animal tissue. These wounds are marked by the rapid spread of the inflammation, the lymphatics showing plainly the inflammation, which may spread from the hand to the shoulder in a very short time. The constitutional symptoms are generally very marked, in most cases being those of pyæmia. There may be a discharge of lymph from the severed vessel—this is known as lymphorrhœa. The constitutional treatment is that of pyæmia, the local that of cellulitis.

Malformations.—Congenital deformities of the hand and fingers are most often seen in the form of supernumerary fingers and thumbs. These may occur in one or both hands; sometimes the abnormal members may have perfectly formed metacarpal bones, the hand in some cases being double. Generally, however, they are rudimentary, and appear as skin appendages or as cleft phalanges. Hypertrophy of a hand or finger may exist. Arrest of development may occur also. *Treatment.*—Rudimentary fingers, when they exist as skin appendages, may be readily excised, but when existing as cleft phalanges they should be removed at some distance from the junction, in order to avoid opening the joint; the resulting stump generally withers later on.

Webbed Fingers.—In some cases all the fingers and thumbs are "webbed," but generally two only are involved. If the fingers are well formed the web may be divided, care being taken that the sides of the wound at the base of the cleft do not unite. When the web is broad it may be divided transversely, and a flap fastened around each adjoining finger (Bryant).

Lack of development or intra-uterine amputation may take place at any point in the upper extremity; or perhaps a single bone, or an articulation may be wanting.

Claw-like hands occur but rarely; they are deficient in fingers and in metacarpal bones. The existing fingers are generally wanting in power. There is no treatment for this condition.

Neuralgia.—Neuralgia of the cervico-brachial plexus manifests itself in acute pains shooting down the arm into the hand; these are accompanied by cutaneous hyperæsthesia. The pain corresponds to the distribution of the sensory branches of the brachial plexus. It is of a dull character, and is frequently worse at points where the nerve-trunks are exposed, as at the elbow, and at points where the superficial nerves emerge from the fascia. Sometimes it is mistaken for the pain of muscular rheumatism. The temperature of the skin of the affected part is reduced, and there may be trophic changes. There may be excessive sweating of the fingers. This disease is often inveterate, and is attended with nocturnal attacks. *Treatment.*—Possible causes must be fully considered, and when a constitutional trouble, such as syphilis or malaria, can be made out, the treatment must, of course, be managed accordingly. The pain must be controlled by the use of anodynes, as morphia, chloral, and the bromides; deep subcutaneous injections of morphia have proved very successful in these cases. Counter-irritation by blisters or by the actual cautery is also effective; electricity in the form of the galvanic current is of great service—the current must not be too strong, nor should it be applied too long at a time.

Neuritis.—Inflammation of a nerve in the upper extremity is occasionally met with. The causes are traumatism, cold, rheumatism, and syphilis; the extension of cancerous disease has caused neuritis, and one case of neuritis has been reported as occurring in typhus fever without other known cause. In an inflamed nerve the axis-cylinder and the medullary contents become disintegrated, the blood-vessels are enlarged, and the neurilemma is distended with serous exudation. In chronic cases there is a proliferation of the connective-tissue. The inflammatory process may be so severe as to cause sloughing of the nerve. This affection is frequently accompanied by trophic changes in the skin of the hand and about the nails. The symptoms are pain and soreness along the nerve, with redness and a bullous eruption

of the skin; hyperæsthesia may be present, followed later on by anæsthesia. The pain is said to be aggravated by the contact of cold and hot substances. *Treatment.*—Blood may be abstracted locally, cooling lotions applied, and anodynes administered. The general health must be looked after, and when there is a constitutional taint it must be treated. In the chronic form, counter-irritation, as blisters, may be applied along the course of the affected nerve. Nerve-stretching has been advised in this affection.

ONYXITIS, or onychia maligna, is an inflammation of the matrix of the nail. It occurs most frequently in unhealthy children, and is excited by some such cause as a squeeze or other contusion. It commences with the usual signs of inflammation, as swelling, redness, and tenderness; there is pain of a throbbing character. This is followed by the exudation of a fetid serous fluid from beneath the nail; finally, the nail becomes loosened and falls off or rolls up at the edges; the inflammation may extend to the bone of the last phalanx. The condition may become chronic. *Treatment.*—In the milder cases this consists simply of tonics internally and water-dressing locally. In the more serious cases some mercurial, as the ung. hydrarg. oxid. rubri, must be applied; and it may be necessary to perform evulsion of the nails, or possibly to remove the nail and soft parts on the dorsal surface of the phalanx. Powdered nitrate of lead has been successfully applied to the ulcers.

PARALYSIS.—(For Infantile Palsy and Lead Palsy, see articles on these subjects.) Paralysis of the deltoid muscle may be caused by injuries, as falls, dislocations, or blows on the shoulder; it may be caused by cold or exposure. The nerves and muscular fibres are in a state of contusion. This may be followed by inflammation involving the shoulder-joint. *Treatment.*—At first rest, then leeches and soothing applications; later on friction may be made, or counter-irritation by blisters, followed by passive motion. Electricity is also indicated. Temporary paralysis of the muscles of the upper extremity may be caused by pressure, as when one falls asleep with the arm hanging over the edge of any object, or when it is held in an unnatural position for any length of time. The loss of motion and of sensation will be confined to the muscles and portion of the skin which are supplied by the fibres of the nerve directly pressed upon.

(For Syphilitic and Skin Diseases, see these subjects.)

TUMORS.—(See also under the head of Tumors.)

Ungual Exostoses.—Although these generally occur on the toes, several cases have been reported in which they grew from the fingers and thumbs. Out of 120 cases of exostosis, 5 were from the fingers and 2 from the thumbs (Bryant). The treatment is simply the excision of the growth, which must be removed well down to its base; when the growth is situated near a joint, care must be exercised not to open the latter.

Muscular Tumors.—Cancerous and vascular tumors and hydatids sometimes occur in the muscles of the upper extremity, but present no particular peculiarities in this situation. The so-called "exercise bone," which occurs on the left arm in soldiers, is an ossification of the muscle.

Tumors of Tendons.—Cartilaginous, bony, cancerous, and fibro-cellular tumors have been reported as springing from, or involving the tendons of the palm of the hand. They all demanded removal. Most tumors connected with tendons are more or less indurated ganglia.

Neuroma.—Painful tumors of nerves occur occasionally in the stumps after amputation of the arm or forearm. They must be removed by very careful dissection, so as not to injure the nerve proper.

Telegrapher's Cramp.—This affection, known sometimes as scrivener's palsy or writer's cramp, is a partial paralysis and a partial spasm of the muscles of the hand and fingers; the cause being, apparently, the fatigue arising from the long-continued use of the muscles, as in writing, telegraphing, playing upon musical instruments, and so forth. The symptoms are fatigue, numbness, and pain in the thumb and forefinger of the affected hand. The affection develops gradually; it may go on to involve the muscles of the hand, forearm, and arm. After a time the pen cannot be held except for a few minutes at a time, unless something be wrapped around it to increase the bulk; the final result is complete inability to use the muscles. The pain may simulate that of rheumatism or neuralgia; there may be burning or tingling sensations; the muscles may become atrophied, and the fingers cold and stiff. The pathology is not well understood. Dr. Gross thinks that it is "simply a local nervous affection of the muscles of the thumb and fingers, originating in excessive fatigue and eventuating in partial paralysis and atrophy." Others hold that it has its origin in the gray cells of the spinal cord; others, that it is a reflex neurosis. *Treatment,* to be effective, must be begun early. Absolute rest from the customary occupation must be insisted on, with counter-irritation and passive motion made at regular intervals; the faradic current may do good. If necessary, the general health must be looked after, tonics, exercise, and change of air being indicated. Various mechanical aids have been made to prevent the occurrence of the spasm, the general principle being to obviate the necessity for rigid contraction of the muscles. (Figs. 789, 790, and 791 in Gross's "Surgery.") These appliances are especially useful in the form designated as writer's cramp. Massage, friction, and percussion of the affected muscles have done good in some cases.

WHITLOW.—This is an acute inflammation of a tendon or its sheath in the fingers; it is a serious affection, and may cause constitutional as well as local trouble. It may be caused by a strain, a contusion, a wound involving the tendon or its sheath, or a foreign body. Ordinarily it begins in the fingers, and spreads into the palm, or even up into the forearm. The local symptoms are those of deep-seated inflammation; the pain, which may extend up the arm, is very severe. There are marked febrile symptoms in the more severe cases. Unless checked the process will go on to suppuration, and even to sloughing of the tendons, and necrosis. It frequently causes a diffuse cellulitis of the hand and forearm. A stiff finger is a very frequent result of this trouble. *Treatment.*—As soon as the diagnosis is made, a clean incision must be made well down to the tendon. This should be made vertically upon the middle of the finger, in order to avoid injuring important vessels. Even if no pus escape, the tension and pain will be relieved and the inflammation checked. If suppuration occur, the pus must be promptly evacuated, for if allowed to remain within the fibrous sheath it does great harm. Poultices must be applied, with soothing applications, and the hand elevated. The bowels must be moved, and antifebrile remedies given. Pain must be allayed by opium. When the hand is affected the treatment is that of deep-seated palmar abscess.

An inflammation of the sheaths of tendons, sometimes called "thecitis," may occur also in the hand and about the wrist and elbow; it may occur in connection with disease of the neighboring bursæ or joints. It may be due to disease, as gout, rheumatism, and syphilis, or to exposure, or to an injury, as a sprain or contusion. It may spread from one sheath to another, resulting in permanent deformity and lameness. The symptoms are pain on movement of the affected tendons (which is often very severe), together with the other signs of inflammation. The disease may spread, invading a great length of tendinous sheath. *Treatment.*—The inflammation should be checked by the abstraction of blood by leeches, and counter-irritation should be made externally with tinct. iodini. The constitutional disease, if any exist, requires appropriate treatment. Pain must be allayed by opium internally and soothing applications locally. If permanent stiffness result, passive motion and sorbefacients are indicated.

Painful crepitation almost always occurs in the tendon-sheaths of the forearm and arm, most frequently in those of the extensors at the outer and back part of the wrist. It may occur in the tendon-sheath of the long head of the biceps muscle. It is due to an inflammation of the sheath of the tendon, followed by a deposit of plastic material, which causes the pain and gives the sensation of crepitation on

motion. The affection often disappears spontaneously, but, if not, rest and counter-irritation will generally accomplish a cure.

INJURIES.

BURNS.—See article on that subject.

Deformities from burns and scalds of the upper extremity are frequently of such a nature as to require surgical treatment. In some cases the whole upper part of the arm has been fastened to the axilla by a cicatricial web, the traction being occasionally so great as to displace the head of the humerus. The development of the extremity may be prevented by the contraction (see Fig. 40 in Bryant's "Surgery"). Movement at the elbow-joint may be more or less completely prevented by such cicatrices. *Treatment* consists in a division of the cicatrix. In doing this, however, in the axillary region, great care must be taken that nerves and vessels displaced by the morbid process are not injured by the section. The subcutaneous tissue must be divided, for it is here that the contraction exists. The section may be accomplished by the division of the flap or by a number of small incisions. After a healthy granulating surface has appeared, the cure may be hastened by "skin-grafting." Burns about the hand and fingers may result in a webbing of the latter; this may be guarded against by keeping the dressings well down in the clefts of the fingers.

CONTUSIONS.—Contusions of the hand frequently give rise to a good deal of pain and swelling. The blows received on the hands by pugilists frequently cause such injuries. When they occur about the joints they frequently disable the parts temporarily. It is often impossible to determine the exact extent of the injury until time has caused the removal of the swelling. Severe contusions of the hand and fingers must be treated by soothing applications, as the lotio plumbi et opii, and the hand supported on a splint with a cotton dressing.

Contusions of the forearm and arm require similar treatment. When in the neighborhood of the elbow or wrist, there are frequently joint complications (see Injuries of Joints). Contusions of muscles may result in a partial or complete paralysis, which is seldom permanent. They may, however, cause atrophy of the muscle: such an injury is, perhaps, most frequently seen in the deltoid muscle, as the result of a fall or a blow on the shoulder. The *treatment* of this condition is at first rest, followed by electricity and passive motion. If a contusion cause much extravasation of blood, cold applications must be made; in some instances an artery may be ruptured, in which case a traumatic diffuse aneurism would form (see Aneurisms). If the force be sufficient to deprive the tissues of their vitality, a contusion will be followed by sloughing. Slight inflammation is frequently set up, which in some cases may become erysipelas or cellulitis.

DISLOCATIONS.—See article on that subject.

FRACTURES.—See article on that subject.

FROST-BITES.—When cold is applied long enough to check the circulation in a finger or the hand, a frost-bite is the result. The appearance of a part thus affected is characteristic: it has a white and waxy look, and is cold and rigid; the blood is driven completely away from the surface. In some cases, when the freezing process has been very sudden, the frozen portion will have a mottled appearance, owing to the retention of the blood in the tissues. There will be the usual constitutional effects, as torpor, and if the exposure be prolonged, death will result. *Treatment.*—This must be very cautiously carried out; the parts should be restored to their natural condition very gradually. The venous circulation may be aided by gentle rubbing in the direction of the venous flow, the arterial by stimulants internally. Friction with snow or ice-water may be resorted to, and after the circulation has begun to return, the temperature of the water may be gradually raised. The after-treatment consists in protecting the parts with a light dressing; tonics may be administered internally. If too great reaction occur, it must be checked by cooling lotions, and, if necessary, by depressants internally. Gangrene may result, and must be treated as when resulting from any other cause. Amputation may be necessary, but should not be done until the limit of the sloughing process has shown itself.

SPRAINS of wrist and elbow; see article on Injuries of Joints.

WOUNDS.—Wounds of the hand and fingers, either incised, lacerated, or punctured, are the most common. This is due to the fact that artisans work constantly with sharp tools, and also, that in adjusting and operating machinery it is the hands that are most exposed to danger. Bleeding must be checked, and the wound thoroughly cleansed, as in any situation. Deep wounds of the fingers, when at all extensive, require careful suturing. When there is reason to suppose that a joint has been opened, the wound, if not too extensive, should be immediately sealed up and rest maintained. Wounds about the proximal phalanges may divide either the flexor or the extensor tendons. In such an event the divided ends of the tendon should be sutured, the wound dressed, and the finger or thumb placed on a splint, forced extension being maintained.

Wounds of the palm of the hand, when they involve either of the palmar arches, are very serious (see article on Wounds). Wounds of the dorsum of the hand, if at all deep, generally divide several tendons. An effort must be made to unite the divided ends, and, if necessary, the tissue must be dissected up in order to secure the tendons, which are apt to retract within their sheaths. After dressing the wound absolute rest must be secured by means of a splint, and forced extension of the hand and fingers maintained.

Wounds of the forearm and arm, if they tend to gape, must be sutured, and if they are extensive, the parts must be supported by means of a splint.

Wounds about the wrist, elbow, and shoulder are rendered serious on account of the proximity of the joint (see article on Injuries of Joints).

Lacerated wounds in which a large amount of skin is destroyed, must be left to granulate; such wounds are frequently caused by the hand or arm being caught in the shafting or cog-wheels of machinery.

Gunshot wounds in the upper extremity are generally serious only when they cause compound fractures, or sever large blood-vessels, or penetrate joints (see articles on Fractures, Gunshot Wounds, and Injuries of Joints). The ball should be extracted, if possible; careful cleansing and free drainage are essential. Such parts as are damaged beyond repair must be removed.

Wounds caused by glass are frequent in the hand and wrist; the hemorrhage is generally considerable (see article on Injuries of Arteries). Care must be taken that all the fragments are removed from the wound.

William H. Murray.

ARMY DISEASES. As long as humanity exists, so will the necessity for association or solidarity, and the power of defence, and even of attack. War seems to be the fatal law of humanity, and its homicidal results appear to be the conservative means of the human species for preventing its degradation, for elevating its physical and moral powers, and for making the stronger races prevail over the feebler. The perfecting of human organizations requiring an armed force, the somascetic efficiency of this force is an object of primary consideration. What constitutes the real value and efficiency of a trained army is the health of its individual members. In spite of the most improved arms and the skilful strategy of able leaders, an army will find itself largely handicapped in the operations of war when encumbered with that evil of incalculable magnitude, a large sick-list; and every disabled man in an army may be looked upon as contributing as much to its inefficiency as two that have been killed outright, since it usually requires the services of several other men to look after him. Sickness does more to render an army inefficient than any other cause. There is an interaction between disease and warfare. Disease enters the camp and the barrack, not always as a single spy, but often in battalions. It gives no quarter, and its ravages kill more than the most bloody battles with the enemy. The only exception to this rule is in

the case of short campaigns; and it is a principle admitted by all great military leaders that the more rapid a war, the less murderous it is. The bloodiest wars of latter times show that about a fifth only of the deaths are occasioned by the fire of the enemy.

In the hard hand-to-hand fights of ancient times, when no quarter was shown, the number of killed was enormous; but with the increase of arms, the number of wounded is far greater than the killed. The astonishing number of killed and the few wounded on such occasions as the sea-fight at Actium, the battle between Cæsar and Ariovistus, or at Cressy, has no parallel in modern warfare. A few figures will suffice to show the relation of the killed to the wounded in more recent battles.

Of 913,967 German soldiers engaged in the Franco-Prussian war, 113,240 were wounded, and 28,282 died on the field of battle or a little later.

In the Turko-Russian war, Scharchowskoi's command, of 18,000 men, lost at Plevna, in July, 1877, 4,553, of whom 2,924 were killed and 1,629 wounded, a relation of 1 to 0.56.

But these figures are far from being so significant as those representing the losses incurred by disease during war. History abounds in references to the grand military epidemics of antiquity, such as the destruction of the army of Sennacherib; the plague described by Thucydides during the Peloponnesian war; the pestilential diseases spoken of by Diodorus Siculus and by Livy, as having made great ravages in the Roman and Carthaginian armies; the disease, thought to be scurvy, that Pliny relates afflicted the Roman army in Germany; the great losses that the army of Severus sustained in the marsh of Caledonia; and the mention by Xenophon, in his "Retreat of the Ten Thousand," of the loss of sight and frost-bites, caused by the excessive cold to which his troops were exposed in the mountains after crossing the Euphrates. It is not necessary to multiply these and other references that go to show that the armies of antiquity were often ravaged by disease, and that military medicine formed a part of the army organization at the end of the Roman Empire.

The army of Gustavus Adolphus, in six months, lost 14,000 men by disease; at a later date there occurred, principally among the infantry, in one month 16,000 deaths by disease, and but 1,000 were killed by the enemy.

It is estimated that more than two-thirds of the losses of the English fleet, during the wars of 1792 to 1815, were from disease.

We know from history of the ravages of scurvy and leprosy in the army of the Crusaders; of the prevalence of typhus in the armies of the sixteenth century; and at the same epoch, of the fearful ravages made by syphilis in the French army in Italy.

On the foregoing points much positive information is withheld from posterity, and we have no means to make a comparison with the more detailed statements that are furnished in modern times.

In the army of Frederick, during the Seven Years' War, 180,000 died, mostly by disease.

On the expedition to Walcheren (1809) the mortality in the English army was 34.69 from disease and 1.67 by the enemy.

The English army lost in Spain, from January, 1811, to January, 1814, out of 61,511 men, 24,930 by disease, and only 8,889 by the enemy's fire, giving a proportion of nearly 12 to 100 by disease, and 4 to 100, or three times less, by the enemy. The mortality was so excessive that being carried to the General Hospital was considered the same thing as being sentenced to death. Admissions to hospital were so frequent that twice the number of the army passed through the hospitals every year.

Of 115,000 Russians, in 1828, there died by disease 80,000, and in consequence of wounds, 20,000.

The French in the Crimea, out of an army of 309,000, had 95,000 deaths, of which 75,000 were from disease and 20,000 from the fire of the enemy. In six months the Allies lost 52,548 men. Of this number, 50,000 were untouched by the Russians, and but 3,800 were wounded.

In the Italian war of 1859, out of an effective force of 200,000, there were entered in hospitals 129,950.

The statistics of the American Civil War* show the killed in battle to be 61,362; died from wounds, 34,729; died of disease, 183,287. There also died as prisoners 29,725 Federals and 26,774 Confederates.

After an unusually short campaign, the Prussian Army and its allies, in 1866, lost 6,427 by disease, principally cholera, and 4,450 by the enemy. In the campaign of 1870–71, in an army of about 900,000, there occurred 40,500 deaths, of which 12,180 were from disease and 28,202 from wounds.

Even in the small army of the United States (23,749), the cases of admission to treatment among white troops, in 1884, were 1,583 per 1,000 of mean strength for disease, and 250 per 1,000 of mean strength for wounds, injuries, and accidents; making the ratio in the 1,000 about equal to the average for the preceding decade.

An analogous circumstance holds in regard to the Invalid Pension List. The writer is informed by the Medical Referee of the Pension Office, that the number of those pensioned for disability incurred by disease is more than four times greater than the number pensioned for wounds.

These figures scarcely need comment. They are, however, worthy of special notice in relation to the Prussian army. A result so favorable speaks well for the sanitary administration of this army, and a similar one has never been shown in the history of war.

It is not, however, during active wars or on expeditions that the greatest mortality is observed. When an army is condemned to inaction during a siege, or even in cantonment after a laborious expedition, sickness rages with the greatest violence. The typhus that tried the Crimean army occurred in the winter following the capture of Sebastopol, and after the conclusion of the armistice. The disasters of that war first drew public attention to the importance of army sanitary arrangements, and the sufferings of the army excited so much sympathy in England that a Royal Commission was appointed to inquire into its sanitary condition. From the report of this Commission it appears that, of all the barracks inspected in the United Kingdom, only one and a part of two others were properly ventilated, and the barracks for more than one-half of the force were wholly unprovided with means of ventilation. Still more astonishing is the statement that the mortality in the army generally was twice as great, and in the foot-guards three times as great, as in the corresponding classes of the civil population. About the same time it was shown, in France, that the mortality in the army was much greater than among the civil population. On this point the query naturally arises, If the army medical officer was so fully aware of the importance of prevailing diseases and the efficacy of judicious sanitary measures in their prevention, how does it happen that a state of affairs so completely opposed to the first principles of hygiene has been permitted to exist? An answer to this question is found in the unsettled relations existing between the military and the medical authorities, or, to put it in military language, the tactical organization clashed with the administrative organization. On the one hand there was jealousy, egotism, and the stiffness of prejudice; on the other, the incompetency and pedantry of a class of professional men not likely to succeed elsewhere. In former days the military authorities held that the duties of a medical officer were to treat the sick and wounded, and any recommendations bearing on the general management of the men were deemed intrusive, and resented as an interference with the province of the commanding officer. "I'll be d——d if I do," was the reply made to Sir Ranald Martin, in India, by a commanding officer to whom he made a simple suggestion regarding the drainage of the camp, with a view to prevent an outbreak of sickness, from which there subsequently resulted a fearful mortality. "Medical opinions are very good when called for," was said to the senior medical officer in the Burmese war; and in the Crimean war, Inspector-General Alexander was informed by a general of division that he "had better keep his suggestions and strictures until asked for" It was not within the

power of the medical officer, as at the present day, to remedy such evils, and if his suggestions were acted upon at all, it was owing to the common sense or good feeling of the commanding officer. Moreover, army medical officers had done nothing for science and for the improvement of medical and surgical practice; nor had they done much more than others in statistics and nomenclature of disease. While the medical profession in civil life was gradually improving, in the army it stood still. In 1810, a mass of papers about the Walcheren fever, and, afterward, on the diseases of the Peninsular war, were sent to the Director-General of the Medical Department, who considered this bulk of records so troublesome that he had them burnt. An analogous circumstance occurred in connection with the Army Medical Museum in Washington. Most of the present material was about to be destroyed or buried by the War Secretary, when Sir Henry Holland, who happened to be in America at the time, and, hearing of this intention, interceded in behalf of the collection, and by his representations and efforts secured the establishment of the museum.

The general health of armies has greatly improved of late, but this improvement did not originate with the medical officers. It was brought about by outside influence. The average army medical officer has been about as apathetic and unprogressive as the line officers, who made strenuous objection to the introduction of the percussion-cap in the place of the old flint-lock, and later, to the substitution of breech-loaders for smooth-bores and muzzle-loaders.

There are, however, many honorable exceptions to this order of things, men who have advocated the principles upon which sanitary ameliorations are founded.

The attention that sanitary reform of the army has attracted in civil life is shown by the citizen organizations, whose acts have been of the greatest benefit in removing existing evils and suggesting remedies. The English army owes its redemption from special sickness and undue mortality to Lord Herbert, Lord Grey, and Florence Nightingale, who did so much toward saving life by working in concert with the War Office.

Lord Herbert's commission recommended six hundred feet of cubic air-space as the minimum in barracks and guard-rooms, and twelve hundred in hospitals. It also secured the abolition of the old rule confining the duties of medical officers to the treatment of the sick and wounded, and the introduction in its stead of an authorized system of sanitary supervision. It is now established by regulation, that any medical officer in charge of troops shall make to his commanding officer any recommendations he may consider necessary for protecting or improving the health of his troops; and should they not be adopted, he must then submit them in writing. In case the commanding officer should not deem it necessary to give effect to the recommendation, he must state, in writing, his reasons for not doing so, and transmit them, with the report of the medical officer, to the commander-in-chief. All sanitary defects, if not remedied, are brought periodically under the notice of the Director-General of the Army Medical Department.

The conferring of advisory powers upon medical officers, for purely preventive and sanitary purposes, resulted in the greatest success. In the Crimea, the excessive mortality and sickness at first, and the singular healthfulness of the English army afterward, on the same spot and under the same military circumstances as before, interested the rulers of armies and brought about great benefits to the soldier. The benefit was so apparent that during the last year of the war, after the introduction of sanitary reform, the mortality in hospitals barely exceeded that of the Guards in their barracks at home. The efforts of persons instrumental in bringing about so much good, also gave impetus to other nations, and various beneficial societies were organized, having for their object the nursing of the sick and wounded. The most notable of these is the Patriotic Ladies' Union of the Red Cross, which originated from small beginnings after the battle of Sadowa.

It is, however, to the United States that Europe owes the first idea of humanizing war. The lesson of the Crimea, having been well studied in this country, resulted in the Sanitary Commission, whose efforts contributed so much to the comfort of the well, and the relief of the wounded.

Soldiers, in most countries, are now furnished with improved barracks, better food and clothing, gymnasia, recreation-rooms, and out-of-door amusements, and their sick wives and children are also provided for, all of which have made not only a reduction of one-half in the death-rate, but have diminished the moral degradation of the soldier, increased his efficiency, and raised his character.

Statistics of the principal armies show that the death-rate has decreased in the last few years. In the last decade it has decreased as follows: in the English army, from 1826 to 1846, the average of 17.5 in the thousand has now fallen to 8.79; French army, 1842 to 1848, 15 to 9.40; Russian, 1841 to 1852, 37.4 to 18; Belgian, 1871 to 1874, 13.8 to 5.4; Austro-Hungarian, 1844 to 1845, 28 to 11.6; Prussian, 1846 to 1860 and since, 6.

Statistics further show that those armies lose the least number of men by death that discharge the greatest number because of physical disability. This phenomenon is shown in the Prussian army when the different periods are compared with one another. The natural decrease of an army is from death and discharges. The Prussian army has decreased as follows: 1858 to 1863, 21.3; 1869, 38.1; 1874, 37.8 per cent.

In the English army it is shown that the Contagious Diseases Act, which has been so severely attacked on so-called moral and religious grounds, has materially lowered the sick-rate at those stations where it is in force. The admissions from causes under its control have, within five years, been reduced to less than a third at some of the large stations; while a comparison of fourteen stations at which the Act is in force, with fourteen to which it has not been extended, shows 54.5 cases in the thousand at the former, and 113.3 at the latter.

The mortality of the English army is a subject of great interest, because, being scattered over all points of the globe, the army is subjected to different climatic influences. The mortality of the English troops serving in the colonies, like that of the troops serving in the United Kingdom, has diminished progressively with the adoption of hygienic measures. From official sources it is learned that the annual death-rate in the army generally averages about fourteen in the thousand. In 1870, Gibraltar, Malta, and Canada were the healthiest stations, showing a death-rate of only 8.7 in the thousand. The United Kingdom came next with a rate of 9.5, while in India the death-rate rose to 22.8. But to appreciate the improvement that has been effected in the health of the army, it is necessary to turn back to the fifteen years preceding the Crimean war, when the death-rate in the United Kingdom averaged 17.5, and that of the army generally 33 in the thousand; while the death-rate in India averaged 62 in the thousand between 1837 and 1853, and 87 in the thousand in the twenty years preceding 1837.

This progressive diminution is also shown in the French army since 1820—a period to which the first documents go back—to have fallen from 27 to 13 in the thousand.

Previously to the outbreak of the American Civil War the death-rate in the United States Army was 26 in the thousand. After the outbreak of the war the mortality from disease was increased more than 100 per cent. In 1869 the death-rate among the white troops was 13, and that among the black 18 in the thousand.

In spite of the introduction of many reforms, comparison shows the mortality in the army to be still in excess of that of the civil population of the same age, living under analogous conditions (13 in place of 11 in the thousand), and that the soldier, who is a picked man, well housed, fed, and clothed, is much oftener sick than the workingman. It has been ascertained during the last thirty years, that the annual number of days of sickness is from six to eight for each workingman belonging to various mutual aid societies; while the statistics of various armies give an annual average of fifteen to twenty days of sickness for each soldier; in other words, the number of days of sickness each year is fifteen to twenty times greater than

the number of the effective force. It may, however, be remarked on this point, that the workingman, having to make a living, does not stop work except for serious illness, while the soldier, finding it to his interest to get exempt from duty, abuses this privilege by going on the sick-list for the slightest indisposition. A recent tabular statement of the morbidity in different armies shows the lowest figures in the Portuguese, Austro-Hungarian, Italian, and Prussian armies, the sick days of each man of the effective force being from thirteen to fifteen yearly; in the French and in the English armies it is from sixteen to seventeen; while in the United States Army it is nineteen among the negro troops, and twenty-one among the white. In 1884, out of an average mean strength of 23,749, there were 41,638 cases of admission to treatment reported in the latter army. Of the white troops the average number constantly on sick report during the year was 1,003, or 50 per 1,000 of mean strength; 809, or 40 per 1,000, were constantly under treatment for disease, and 194, or 10 per 1,000, for wounds, accidents, and injuries. Among the black troops the average number constantly on sick report was 44 per 1,000; of which 33 per 1,000 were under treatment for various diseases, and 11 per 1,000 for injuries.

Having shown in this brief outline the significance of losses to an army from sickness, it is unnecessary to point out the urgent need for careful study of the causes and prevention of the principal diseases that scourge and encumber an army, and thereby affect the operations of war.

The diseases observed among armed forces, whether afloat or ashore, comprise almost all those which are met with in civil life, such as fevers, affections of the various organs, syphilis, gonorrhœa, alcoholism, etc., all of which are so well described in numerous works, and their treatment so well formulated, that they would not be mentioned here, except for their frequency in armies, and to insist upon their etiology, their mode of development, and their prevention.

The three principal causes affecting the health of the soldier are his environment, his manner of life, and his food; and it is these three influences alone, either separately or combined, that modify the soldier's sickness. The first of these is typified in the accidents arising from atmospheric or telluric influences; such as rapid death from heat or from cold, the transient influence of the seasons, and the slower but more durable effects of climate witnessed in dysentery and the unfortunate action of malaria. The second cause relates to the mephitism of dwelling-places, and the miasma arising from overcrowding, imperfect ventilation, want of cleanliness, and inattention to personal hygiene; the effects of which are seen in typhus and typhoid fevers, the exanthemata, and in the general tendency to adynamia. The third cause concerns the diseases brought about by vicious alimentation. It is seen in scurvy, which has existed as a leading disease in armies of every age, not only in a fully developed form, but as a uniform taint complicating other diseases.

The prevailing diseases in armies are mostly acute; and at least two-thirds of them being zymotic, are consequently preventable.

It is desirable to have clearer notions regarding the term *zymosis*, which is used in speculative pathology to denote the action of a peculiar and little-known process analogous to fermentation. This morbid principle, acting presumably in the blood, causes profound changes in the system, and produces wide-spread constitutional affections among masses of men.

The most widely prevailing doctrine of the present day respecting the origin and communication of diseases is that known as the germ theory. Special organic forms known as mycrozymes, bioplasts, bacilli, etc., alleged by various pathologists to be found in contagious fluids, have been the subject of much discussion; some contending that they are of fungoid growth and enter the body as parasites; others that they are germinal masses derived from normal cells, and owing to a series of changes in existing matter under new circumstances; while a third class deny positively that any such germs exist. The elements or factors giving rise to many of the foregoing conditions are known as *zymotic*, a term that the writer formerly attempted to explain in a cyclopædia article. The word has been objected to by many as an improper designation, but, it seems, on insufficient grounds. Like the atomic theory in chemistry, it is not clearly descriptive, but is admitted into the standard nomenclature of medicine as a convenient expression to include all that class of diseases communicable from existing foci, and capable of being prevented by hygienic or other conditions.

As before remarked, there are no diseases peculiar to soldiers. It is in their mode of action only that a difference exists between army diseases and those of civil life; so the mention will be limited to the principal diseases that encroach most on the usefulness of the army.

Among the privations incident to war is the atmospheric exposure to which the soldier is subjected. Sleeping on the bare ground, and often drenched with rain; standing in trenches exposed to snow and cold, and making long marches under a tropical sun, are a few of the vicissitudes that debilitate and render him susceptible to the action of the seasons. The diseases developed by the influence of the seasons present in the soldier no particular character calling for remark, unless it be their short duration, the regularity with which certain of them return—such as cholera morbus, malarial fever, and dysentery—and the occasional tendency of some to become endemo-epidemic. The influence of cold, damp nights followed by hot days, and the action of intense light, are the generally admitted causes of the purulent ophthalmia observed in European armies. In Algeria it has been observed that ophthalmia is often developed in men who sleep outside of their tents, directly exposed to nocturnal radiation. In Europe atmospheric vicissitudes are often known to have produced the same effects, purulent ophthalmia having often been observed among harvesters who had exposed themselves to cold while covered with sweat. An epidemic in a French orphan asylum broke out after a shower that had wet the children; and it is thought that the epidemic of the allied armies of Europe, in 1813 and 1815, was in great part owing to the necessity of bivouacking at night on the cold, damp earth, after fatiguing marches and incessant fighting.

Climatic diseases are said to be only those of the season carried to a higher power. Observation and experience seem to be our only guides as regards climate. Up to the present time climatology has given us many figures with but few results, and topography teaches nothing upon the salubrity of a country. It does not explain why cholera is in India, plague in Egypt, and yellow fever on the shores of the Gulf of Mexico. Nor does it tell why fevers spare New Caledonia, in spite of the existence of numerous marshes, and why they ravage Madagascar, in spite of its grand chain of mountains.

The meteorological influences of a climate modify the telluric conditions, alimentation, habits, etc.; and, generally speaking, the diseases of hot countries correspond to those of the hot seasons, and those of cold climates to those of cold seasons.

Affections of the organs of respiration and rheumatism are mentioned by systematic writers as prominent diseases in cold countries. Rheumatism, however, belongs rather to temperate climates. It is met with in India and Egypt, but is unknown in the polar regions.

In Nova Scotia the English army furnished a proportion of 30 cases of rheumatism to the 1,000; while under the more temperate climate of the Cape of Good Hope, there were 57 in the 1,000. On two successive voyages to the Siberian Arctic the writer did not meet with a single case of bronchitis or rheumatism, nor even a common cold, except in Eskimos, who, by the way, appear to stand cold not so well as white men. During the last few years, meteorological parties at the circumpolar stations have escaped all sickness, and sledging expeditions have been exposed to continuous cold of $-50°$ with no great inconvenience. On the other hand, soldiers have been known to succumb in great numbers from asphyxia caused by cold, when the thermometer marked a temperature comparatively high. The history of congela-

tions in armies shows that what played a greater rôle than the cold itself, was the state of inanition brought about by unfavorable hygienic conditions. Pages could be filled with historic mentions of losses caused by cold in various armies, from that of Xenophon down to modern times.

According to Forestius, soldiers have been found frozen and standing with their arms in their hands, as if struck with catalepsy. Larrey observed the same thing on the retreat from Moscow, and the incident furnished a motive for verses to Victor Hugo.

In 1709, Charles XII. lost a part of his army from cold in Russia, and in 1719, 3,000 of his men perished from cold in Finland.

In 1742, the French army, in passing the defiles of Bohemia, lost in ten days 400 men from cold. The "Grand Army" of 400,000, in six months after the retreat from Moscow, numbered but 3,000 men, cold being the principal cause of disaster.

In 1845, a column of French troops in Algeria, being overtaken by snow and a north wind, lost 208 men in forty-eight hours, and 521 others were more or less frost-bitten. Analogous accidents have happened to the French in Algeria on three other occasions.

In the Crimea, 1,179 of the French troops perished from cold, and 4,023 were frost-bitten.

The English had 2,389 cases of congelations and 463 deaths. The thermometer in the Crimea was never very low, and it is believed that congelations were owing more to the debilitated condition of the soldiers than to the degree of cold. A report suggests that it would be better to speak of these accidents as "gangrene owing to scorbutic tendency exaggerated by cold."

At the risk of incurring the reproach of superfluity, it may be remarked that warm clothing and plenty of good food are the best protectors against excessive cold. A small quantity of spirit may render great service, but taken in large quantity it is suicidal. The men should be allowed sufficient opportunities to make hot soup or drink. Had the armies mentioned in the foregoing sum mary been well fed, it is certain that they would have resisted the cold with no great loss. The well-fed and well-clothed command of General Crook, U. S. A., during the Powder River Expedition of 1876, consisting of about two thousand men, was engaged in an active campaign in upper Nebraska during the months of December, January, and February, with the thermometer never above freezing, and often down to 40° F., yet the sick-list was small, and the number of frost-bites (31) was comparatively trivial. Among 350 Indians who made part of the expedition there occurred no frost-bites, and three only are borne on the return of sick and wounded. A detachment of 200 men, under Major Campbell, U. S. A., has marched over nine hundred miles in snow, without the occurrence of frost-bites or any case of serious illness. It is the opinion of experienced soldiers that good discipline does much to prevent the injurious effects of either heat or cold.

The extinction of vitality by extreme *heat*, common among soldiers serving in hot climates, is sometimes witnessed in temperate climates during what is known as the heated term, and often has victims in European armies.

On July 8, 1853, two-thirds of the men in a Belgian regiment on the march from Beverloo to Hasselt were struck down by heat. Only 150 of the regiment were able to reach Brussels. An analogous fact was observed in the army of Prince Henry, on a forced march from Bernburg to Dresden.

During the Italian war heat-asphyxia was frequently observed in the French army. On the 4th of July, 2,000 men of one division fell in the ranks.

The Baden army lost eight men in one company a few years ago; and the Austrian army lately lost six men in one regiment.

Sunstroke does not appear to have occurred often among the French army in Mexico. It is frequent at Mauritius among English soldiers, while it is rare at the Cape and the West Coast of Africa, and is almost unknown in Senegambia. In 1883 there were 28, and in 1884, 21 cases of sunstroke in the United States army.

Whether sunstroke be regarded as a hyperæmic condition of the brain, or as an acute neurosis of the vaso-motor system having the medulla oblongata as a centre, it is probably owing, in all its forms, to changes in the internal organs brought about by high, close, and humid temperature. Whatever be the variety, death is produced by paralysis of the heart, and occurs generally in men whose condition is lowered by such causes as diseased viscera, crowd-poisoning, and great fatigue. Sunstroke is relatively infrequent among cavalrymen; it is generally confined to the infantry.

It requires no great foresight to suggest the precautionary measures that should be taken against sunstroke. Marches and drills should be so regulated that the men may rest during the hottest part of the day. Should circumstances render the exposure imperative, the men ought to march in open order, as far apart as circumstances will permit, and during a halt they should not be allowed to lie on the bare ground.

Dysentery, until lately one of the most terrible scourges of armies, is evidently influenced in frequency and gravity by the heat, not only of hot countries, but by that of the summer and autumn in temperate climates.

In 1415, the army of Henry V. was reduced by dysentery to one-fourth of its effective force, before the battle of Agincourt. From this time onward history shows dysentery to be one of the commonest of diseases in armies. It does not appear to have been very frequent or grave in the army of the United States, while at the siege of Metz there were 514 patients in hospital for dysentery.

As regards the etiology of this affection, different results have been obtained from a large number of observations; but it is most generally admitted that the disease depends on a certain focus of infection, and that it dies out on the removal of the cause.

In 1773, half the English army at Hanau had dysentery. It decreased after the abandonment of the camp. The same thing took place in the change of camp in the army of Prince William of Hesse, in 1778. An instance is known of a regiment being affected with dysentery every time it went into a certain camp. Diarrhœa and dysentery in the United States army are reported at 209 per 1,000 of the mean strength for the year 1883.

The causes of dysentery are moisture, common to habitations on low grounds, the contamination of impure air, exposure to rain and wet, too light clothing, and the influence of the seasons and conditions of the weather. It does not, however, depend entirely on surface and on seasons; for it sometimes occurs on ships in winter. Other causes are cold and damp nights following hot days, rapid changes of temperature, and malaria.

In the English army it makes its appearance in the middle of summer and the beginning of autumn. In the Prussian army it makes its appearance from June to September, and prevails but little among the cavalry—a fact thought to be due to their better clothing, their freedom from over-exertion, and their higher pay, which makes better food possible.

A study of the geographical distribution of dysentery shows the existence of a constant relation between that affection and abscess of the liver, and that the places where dysentery prevails with greatest force are not those where the gravest fevers are observed. Hepatic abscess appears to be most common in India and in Algeria; in fact, its medical geography and the circumstances under which it occurs are the same as those of dysentery.

Chronic diarrhœa prevailed to a considerable extent during the late civil war. Persons are now on the invalid pension-list for this disease, contracted during the "Chickahominy campaign," twenty years ago; and an additional fact—more curious from another point of view than a medical one—is that many of these pensioners weigh two hundred pounds! Diarrhœal diseases show a proportion of 219 per 1,000 of mean strength in the United States army for 1884.

The frequency of *palustral fevers* in armies has been witnessed from the time when the Gauls, under Brennus, encamped under the walls of Rome, were scourged and despoiled by malarial fever. In the year 208, the Roman

army of 80,000 men lost, in Scotland, from this cause, 50,000 men. More recent facts furnish numerous examples of epidemics owing to telluric influences.

No military disaster caused by palustral infection was more complete than that following the English expedition to the island of Walcheren in 1809. On this occasion, it is said, the English were conquered before the battle. Out of an effective force of 39,219 men, there succumbed to the fever, between August 28th and December 23d, 4,175 men. The number of admissions to hospital, from August 21st to November 18th, was 21,846. After the return to England there were 11,503 additional cases. But 217 men were killed by the enemy.

Malarial fevers prevailed in the French army during the Morean campaign in 1828, as also at the Crimea and during the occupation of Rome. But it is among troops stationed in Algeria, India, and the Southern States of America, that the gravest forms of impaludism are found.

Some knowledge of the geographical distribution of malarial fevers is indispensable to show what are the surrounding conditions favorable to the development of these diseases, and as a preliminary to the study of their etiology.

Broadly speaking, malarial fevers increase in frequency and gravity as latitude diminishes; but this progression lacks constancy and uniformity. Although these fevers increase in gravity and frequency as the equator is approached, their distribution does not correspond exactly with the isothermal lines. Tropical countries are often exempt, while others, in a high latitude, have these fevers. They are found in Sweden as high as latitude 63°, in some parts of Ireland, and on the shores of the Baltic. On the other hand, in intertropical countries like Australia, Tahiti, and the Island of Reunion, they are rare, and New Caledonia is completely exempt. Marshy coasts and low humid plains are the objective causes of malarial fevers, and the surroundings most favorable for their development; yet the marsh itself is not a cause, for there are marshes in hot countries that are not febrigenous. The city of Mexico, situated on a high plateau, surrounded by lakes and marshes, exemplifies the fact that vertical climatology corresponds to horizontal climatology: there malarial fevers are almost unknown.

In Europe malarial fevers seem to have almost disappeared with the advance of civilization, yet they are common in the Belgian army, having reigned epidemically some years ago in the garrison at Antwerp and among the troops at Beverloo. They are also observed epidemically on the littoral of France from Bayonne to the mouth of the Loire; in Corsica; and in Hungary, on the Danube. But it is in Greece and Italy where they take a grave form. In Greece palustral affections count for two-thirds in the mortality. During the French occupation of Rome, out of 1,000 patients in hospital more than 500 were there for fevers. Every school-boy knows of the sad insalubrity of the Pontine Marshes, and not less celebrated is the *Palus Mæotis* in the Sea of Azov, whose cachectic inhabitants are mentioned by Hippocrates. In India the mortality from fevers—intermittent, remittent, and pernicious—counts for 40.20 in the 100. In Algeria they count for 20,697 in 42,507 patients, or 48 in the 100.

They prevail in grave form in Egypt, Abyssinia, the French Antilles, and in Guiana. At the latter place, 12,000 French colonists from Alsace and Lorraine were reduced in three years to 2,000. The latest returns of the United States army place malarial diseases at 208 per 1,000 of mean strength.

In North America the palustral influence is much greater on the shores of the Gulf of Mexico and in the Antilles than upon the coast of the Pacific. This is fully shown in the statistics of the war of the Rebellion. Figures from the "Report of the Sanitary Commission" also show an increase in the frequency of fever in the United States as the equator is approached. In the northern posts, at a distance from the sea and the great lakes, they give 151 sick in the thousand; in the lake region, 193; in the seaboard stations from the Delaware capes to Savannah, 370; on the Lower Mississippi, 383; in Eastern Florida, 520; and in the Southwest, 747. A few years ago, malarial fever prevailed to such an extent at the Washington Arsenal and at Fort Washington, on the Potomac, that there were scarcely enough well men to do guard duty. The latter post has been abandoned, mainly on that account. At Fort Foote, near Washington, days have occurred when there were but three persons in the garrison that did not suffer from ague. An officer who served at that post thirteen years ago still suffers from the effects of malaria when the weather changes, notwithstanding the fact that he has served most of the time since in non-malarious localities.

Experience shows negroes to be less subject to palustral miasm than others, but they partly lose their immunity after living a long time in a non-malarious climate. On the English expedition up the Niger, composed of 145 whites and 158 negroes, there were among the whites 130 cases of fever and 40 deaths; among the negroes 11 only were slightly attacked, and they had passed several years in England. A departure from this rule has lately occurred in the United States army, the returns of which for 1884 show malarial diseases to have been more frequent among the black than the white troops; the admission rate for the former being 62 per 1,000 higher for this year, and 14 per 1,000 higher for the previous year. The fact that the negro regiments are serving in a specially malarious region is supposed to account for this increase.

So much has been published upon the etiology and mode of development of these fevers, that to give here even a summary would be needless repetition of what has been better stated elsewhere.

A disputed question is in regard to the influence of drinking-water in originating and propagating these fevers. Our knowledge of the question is mainly empirical. Dr. Blanc, who has travelled through Abyssinia, claims to have escaped the fevers of that country by never drinking water unless filtered or boiled; an English officer, who submitted to the same rule, was equally preserved, while all the other persons taking part in the same mission were attacked with fever or dysentery, on account of not having been willing to take the same precautions. The writer has had a similar experience, never having been ill while serving at such malarious posts as Savannah, New Orleans, and Brownsville, Tex. Water, except for purposes of swimming and navigation, received only hydrophobic attention; and during two epidemics of dengue at Savannah and Brownsville, the writer does not know personally of a single individual that escaped except himself. An experienced army officer informs the writer that he considers bad cookery to be the main cause of sickness during campaigns, in connection with drinking imprudently of water, either good or bad.

The irregularity of the period of malarial incubation is sometimes witnessed in an outbreak of fever when the patients have quitted the unhealthy climates. Soldiers who in Algeria have never had fever, are often attacked with it on the voyage to France, or a little time after landing. An epidemic of intermittent fever occurred at Cook's Inlet, Alaska, on a high bluff, among persons who had lately arrived on a ship from a malarious locality The writer has seen a case of intermittent fever in a sailor on board a ship, while in the ice off Wrangell Island. It was ascertained that before coming north this man had been on the Isthmus, near the Chagres River. The slowness of the poison is often seen in the form of cachexia common to the indigenous population of unhealthy countries. This cachexia has much to do with the mortality of palustral fevers, and complicates other diseases. An effort has been made by certain writers to differentiate the so-called typho-malarial fever, but, it would appear, upon insufficient ground. This supposed type, which writers on the subject naïvely say closely approximates remittent fever and typhoid fever, and may be confounded with them, is either typhoid fever, or it is remittent fever in which the symptoms are complicated by the adynamia brought about by the scorbutic taint and by chronic ma-

larial poisoning. The clinical impossibility of diagnosing this apocryphal type, and the absurdity of introducing a new term which has not even the merit of a convenient abstraction, is apparent to any one that has had any practical experience with malarial fevers. We can with the same propriety speak of malario-syphilitic fever or of typho-malarial epilepsy.

Military hygiene, being rarely able to effect such radical and efficacious prophylactic measures as the drainage of marshes and the cultivation of the soil in palustral localities, must take other means to prevent the extension of malaria in hot countries. Sufficient importance is not given to hygienic considerations, although we have in the present age much surer means of ascertaining the insalubrity of localities than that adopted by the ancient Greeks and Romans, who, before founding a city or establishing a camp, examined the viscera of animals immolated for the occasion, and if the priests found the spleen or the liver diseased, the gods were declared to be unpropitious, and they went elsewhere to found a place more agreeable to the gods and more favorable to men.

It is not advisable to take an army into a malarious country during the fever season, and in localities where malarial fevers prevail it is wise to retire to high land during the epidemic period, if practicable. Arabs and the inhabitants of the Roman Campagna leave the plain for the mountain during the season of fevers; the English, in India, have established sanitariums in the hills, and the French, at Guadaloupe, have a similar establishment.

Troops in a malarious country should not be made to undergo any great fatigue, and during the prevalence of fevers the soldier should be exposed as little as possible to atmospheric vicissitudes, such as the morning dew, the mid-day sun, and the chill at night. When such exposure is imperative, the administration of quinine, or, as is preferred by most French surgeons, the serving out of black coffee, is the best prophylactic treatment. Many facts having testified in favor of quinia as a prophylactic, it is given the preference by English and Americans; but the French physicians are generally unanimous in their disbelief of its efficacy, and prefer coffee to quinia.

The experience of the Ashantee war shows that alcoholic drinks are hurtful. The men that did not touch the supplementary ration of rum presented a morbidity and a mortality inferior to the other soldiers.

The acclimation of troops in a malarious country cannot be counted upon, experience having shown that the mortality increases with the duration of the sojourn. Figures show the mortality during the first year's sojourn in French Guiana to be 15 in the 1,000 men. This mortality increased with the duration of the sojourn, having reached 102 in the eighth year, and in the ninth 125 in the 1,000.

Infallible proofs of the non-acclimation of troops show the necessity for frequent renewal of garrisons in localities devastated by malaria. The French renew their garrison at Mayotte every year; in the other colonies, less malarious, every four years.

It is thought by many that malarial fevers and *yellow fever* are essentially the same, and that they assume more or less the type of one another, according as they are modified by intensity of cause and by prevailing constitution. The opinion that yellow fever arises from miasmata or infective material is sustained by numerous facts; but the fever itself is a morbid entity perfectly distinct from the palustral fevers, and presents certain analogies with typhus. Yellow fever does not prevail to so great an extent among the land force as it does on ships, where the infection readily takes up its abode; and it is demonstrated that ships more than men propagate and import the epidemics that have prevailed at commercial seaports from time to time.

Columbus having landed at San Domingo in 1493, lost the greater number of his crew from what appears to have been yellow fever, and shortly after his return to Spain an epidemic of yellow fever prevailed at Barcelona. It is proved that yellow fever is an essentially importable disease, and that the ship is above all to be feared. The ships that have imported epidemics into Europe were from Havana, where the disease is endemic. A singular thing in connection with the endemicity of yellow fever is that it has never been brought into Europe from Africa, where it is also endemic.

At the siege of Pampeluna, in 1823, the French prevented its introduction and spread in their army by excellent, but very radical, procedures, which consisted in burning an infected ship and ordering all the sick out of the town to surrounding country houses. Before the latter measure was executed it became necessary to threaten a bombardment of the town in order to hurry the tardy inhabitants. The French also suffered during their occupation of Mexico in 1862. The fever broke out among the troops six days after landing in Vera Cruz, and it also attacked the fleet. The negroes of the Egyptian battalion had not a single case of yellow fever during a sojourn of four years at Vera Cruz. An epidemic of typhus prevailed on board the ship that took these negroes to Mexico. As a rule, negroes are exempt, but this fever prevailed among the negro troops at New Orleans during the war of secession, and caused considerable mortality.

High land seems to furnish a safe refuge in time of yellow-fever epidemics. The fever has, however, prevailed in Caracas, 3,000 feet above the sea-level; in Cuzco, at an elevation of 11,378 feet, and even in other places in the Andes, at 14,000 feet.

Acclimated persons are less liable to this fever than new-comers, hence the necessity does not exist for a frequent change of garrison in yellow-fever countries. In the matter of individual prophylaxis, excesses of all kinds are to be avoided, especially in alcoholic drinks. Exposure to the sun, errors of hygiene, and fatigue, are also to be guarded against. During the epidemic of yellow fever that prevailed among the United States troops at Brownsville, Texas, in 1882, such measures as isolation of the sick, and a thorough police and disinfection, were unsuccessful. Abandonment of the infected locality, on the twenty-third day of the epidemic, was followed by better results.

No epidemic of *cholera* is known to have prevailed in Europe among armies before 1830; but the English army has been ravaged by it at various times in India since 1757.

A division of 5,000 men, under Colonel Pears, in 1781, lost in one day 500 men. But the saddest of these epidemics occurred in the division under Hastings, in 1817. The onset of the disease was so sudden that sentries fell as if struck by lightning, and it took three or four men to stand a tour of two hours. Five thousand men died in five days, and the command became nearly extinguished.

In 1821 cholera made such ravages in the Persian and Turkish armies, that they were obliged to put an end to warlike operations in Mesopotamia. The armies imported the disease to their respective countries. Armies take a great part in the distribution of cholera. It was carried, in 1830, by troops engaged in putting down the Polish Revolution, into Russia, England, and even to America. Since then nearly all armies in the field have been affected with it. In 1866 Prussian troops carried it into Bohemia, and in 1854 the French took it from Marseilles to Gallipoli and Varna, thence to Dobrudscha, Corsica, and numerous localities near the Black Sea.

A great number of facts show its distribution by the army in America. In 1866 it was transported by recruits from New York to San Francisco, Texas, Louisiana, and Savannah. The writer was present during the epidemic among the troops at the latter place, and witnessed it from the first case to the close. The same year it broke out in Brazil, Montevideo, and Buenos Ayres, and was imported by contending armies into Paraguay. These facts could be multiplied almost indefinitely, as well as those that show the origin of an extensive epidemic from a single person coming from an infected locality.

During a time of peace troops generally participate in cholera with the inhabitants of the place of garrison. The military population at Paris, in 1832, 1849, and 1853 to 1854, have suffered much more than the civil population. Among the inhabitants the mortality was 14.76 in 1,000, while it was 42.59 in the 1,000 among the garrison

troops. In the United States the epidemic of 1866 showed 77 in the 1,000 for the white, and 135 in the 1,000 for the black troops.

The course of cholera is greatly influenced by the surface of the soil and by the character of the drinking-water. An epidemic is worse in those parts of a city lying in a valley, while hills generally escape. Poor water, narrow streets, bad and crowded quarters, bad privies, etc., influence the course of cholera as they do that of typhus. In the contrary condition the epidemic cannot take footing. Psychical depression, like fear or terror, favors the infection, and the acclimatized are less affected than new-comers.

The prophylaxis of cholera requires the general demand of hygiene. Small rations of rum and cognac are recommended by some physicians. Disinfection and quarantine measures should be systematically enforced, and proper measures should be taken to sequestrate the sick.

Typhoid fever, one of the most frequent diseases among soldiers, and standing next in importance to phthisis, is considered as one of the best gauges of the sanitary state of an army. Its frequency in comparison with consumption places consumption in the ascendency. There is a relation of three to five in the Wurtemburg contingent of the German army. The malady is on the decrease in the Austrian army; on the increase in the Italian; in the Prussian army the number of cases has been sometimes greater, sometimes less, but during late years the disease has been less prevalent than formerly; while the number of cases occurring in the French army for several years past has risen by some two or three in the thousand.

Twenty to thirty years of typhoid fever in armies shows the mortality in the Prussian army to be 15.7; Russian, 151; Austrian, 295; Italian, 151.4; English, 91.27 per 1,000. In the United States army from 1867 to 1883, in an annual mean strength of 26,229, the annual average of typhoid fever gives 3.58 in the 1,000. The rate for 1884, 11 in the 1,000, is not only three times higher than the average annual occurrence for the previous sixteen years, but it is double the highest rate recorded since the Civil War. The cavalry has suffered from this disease largely in excess of other branches, and it is thought that the fever was disseminated by 3,000 cavalry recruits who during the year had been subjected to filth-poisoning and then sent to distant frontier posts. Statistics of mortality in armies show the mortality to be greater in the first year of service, and the disease more prevalent among young recruits than among old soldiers. The character of the drinking-water is thought to influence the development of this fever. An instance is known of pump-water being contaminated with organic matter from the manure of a horse stable; the source of the difficulty was removed and the typhoid ceased. The months of August and September, during the autumn manœuvres, are the occasions for the infection in France and Prussia. It prevails most in the Austrian army during the July manœuvres. In Munich it reached its maximum in March.

Bad water is thought to be the source of numerous epidemics; but many are opposed to this supposition. Collections of filth may act as a focus of infection, and soil impregnated with urine and fecal matter, putrid gases, etc., may be considered as etiological factors. In 1865 the mortality in the Prussian army was twenty-five per cent., but under the cold-water treatment it has fallen to fifteen per cent. Sanitary measures sometimes fail to eradicate the disease from certain military posts and positions. At several posts in Bengal it has become so incorrigibly endemic as to necessitate their military evacuation.

A chapter might be devoted to the historic pathology alone of *typhus*, which has prevailed as a formidable epidemic in armies in the field from 400 B.C. to latter days. It would be an extensive study to note the effects of this one disease on military operations in past times. During peace it is of subordinate importance. It prevailed extensively during the Peloponnesian war, and in 1486 in the army of Ferdinand the Catholic. It is, however, during the sixteenth and seventeenth centuries that we hear most of typhus. In 1790 the Russian army had to suspend operations against the Turks in Little Tartary on account of typhus; and it was from this disease here, and at this time, that the philanthropist, John Howard, died. The disease took footing in England and in Germany during the Napoleonic wars, and hardly any other epidemic has equalled it in extreme mortality. At the siege of Torgau 30,000 men died of it in a few months, leaving only 5,000. During the Crimean war it rose to a high figure. It is epidemic in some parts of Germany, and is carried from time to time into the army.

Typhus is reported not to have prevailed in the United States army during the war of secession; but the authors of the statistics have confounded under the name of "camp fevers," typhus, typhoid fever, and malarial remittent. This name has been given without reason to exanthematic typhus, to which it should not apply. Of late years, however, typhus is comparatively infrequent, and it never gains much of a footing during peace. History shows it to be developed in the field, or under such circumstances as crowding, impure air, damp, etc. In the ancient pest of Athens 400,000 men are reported to have died in 10,000 houses. Fatigue and psychical depression have much to do with the causation of typhus.

Of all the diseases that impair the efficiency of the army *phthisis* is the most permanent and omnipresent. Its mortality in most armies has decreased in the last two decades. In the English army from 1840 to 1846 the death-rate from phthisis was 7.86; 1859 to 1866, 3.1; 1867 to 1871, 2.7. In the French army, 1863 to 1869, 2.28; 1874, 0.98. Italian army, 1871 to 1875, 1.22, compared to 2.80 in former years. Austrian army, 1840 to 1845, 7; 1875, 2.5. The decrease is most constant in the Prussian army. It fell from 1846 to 1863 to 1.28; in 1876 it was 0.81. The returns of the United States army place consumption and other tuberculous diseases at 5 per 1,000 of mean strength.

The development of tuberculosis in soldiers is owing to the influence of general conditions, such as organic debility, living in badly ventilated, crowded, and dirty quarters, want of exercise, confinement, uniform and insufficient diet, and inherited feebleness. Its prevention is simply a question of hygiene and recruitment. The strict examination of recruits is as much in the interest of the army as the attention to the sick, and there is no doubt that much sickness could be prevented by rejecting men who are not strong enough to meet the requirements of the service. All the diseases of the respiratory organs together do not assume the numerical importance of consumption. An apparent deviation from this rule is found in the returns of the United States army for 1883, which place diseases of the respiratory organs first in numerical importance, 64 per cent. being catarrhs of the upper air-passages.

Diseases of the *circulatory organs* are more common in the army than in the civil population. The frequency of "irritable heart" in the soldiers of the American Civil War was owing to prolonged fatigue, mental excitement, and vicious alimentation. The loss in the English army from 1867 to 1871, from heart disease, is placed at 1.46, and the invalided at 2.1. Aneurism is eleven times more common in that army than in the civil population.

Small-pox in armies, formerly very frequent, is now relatively infrequent. The earliest record of small-pox influencing the operation of war is met with in the Koran, which speaks of the discomfiture it caused Abraha's army in the year of Mahomet's birth. It probably prevails to about the same extent as among the civil population, but the mortality is much greater. During the American Civil War there were 1,310 cases of small-pox the first year with 412 deaths; in the second year, 2,822 with 1,132 deaths.

During the Franco-Prussian war, 1870 to 1871, the mortality from small-pox in the army of Paris was 6.76 in the hundred. The German army, which had been carefully vaccinated and re-vaccinated, lost during the whole campaign but 261 men from small-pox, out of an effective of 913,967 men. After the war it was reintroduced into the Prussian army by French prisoners. From

1869 to 1871, but 2 cases are reported. In the small army of the United States, 4 cases are reported for the year 1883.

Other eruptive fevers, like *measles* and *scarlatina,* are found as often among soldiers as among children—a circumstance that shows the analogy between the diseases of the soldier and those of children. In fact, stomatitis, mumps, diphtheria, and cerebro-spinal meningitis occur with the same frequency in military hospitals as in children's hospitals.

From 1832 to 1859, measles was the cause of 27 deaths in the 1,000 among the garrison of Paris. It was epidemic in several garrisons during the siege. During our Civil War there were 21,676 cases with 551 deaths the first year; in the second, 16,345 with 1,313 deaths. The men attacked in both countries were almost exclusively young soldiers from twenty to twenty-two years old. Epidemic capillary bronchitis is often developed in connection with the eruptive fevers, and especially with measles. It was developed at Metz at the same time with numerous cases of measles, and under analogous circumstances, namely, during cold weather and on the arrival of conscripts. Mortality from scarlatina in the garrison of Paris from 1832 to 1859, was 7.7 in the 1,000 of general mortality, while it was only 3 in the 1,000 among the civil population.

In 1837, 1840, 1848, and 1849 the number of deaths rose above the average. Eruptive fevers developed largely in all the French garrisons in 1840 and 1848, and at the same time there were numerous epidemics of capillary bronchitis and cerebro-spinal meningitis. The mortality from scarlatina, like that from measles, has diminished since 1862, the figures showing about 4.7 in the 1,000 of the general mortality. Epidemics of cerebro-spinal meningitis have coincided almost everywhere with epidemics of the eruptive fevers, and their development has been favored by the same general conditions—the arrival of recruits, cold, and the prevalence of eruptive fevers. Epidemics of cerebro-spinal meningitis, remarkable for their extreme gravity, have prevailed in the French army since 1837, both in France and Algeria. The epidemic of Metz in 1849 extended to the civil population. During the winter of 1844 the epidemic was observed at Gibraltar, but was more severe among the civil population than the troops. In the winter of 1860–61 numerous cases of cerebro-spinal meningitis occurred in the garrison at Arnheim, Holland. The frequent coincidence of the eruptive fevers and cerebro-spinal meningitis would seem to indicate an identity of cause for both. Indeed, there is much evidence to support this assertion in the analogies observed in the symptoms and complications of cerebro-spinal meningitis and of scarlatina.

Other virulent eruptions may attack the soldier, such as those spread all over the globe in anomalous forms and known by the various names of yaws or frambœsia, the sibbens of Scotland, the radezyge of Sweden and Norway, the falcaldine, scherlievo, etc.—all of which are forms of syphilis on which local circumstances have imprinted particular characters.

Of all the causes among a soldier's personal habits, the one that brings him oftenest to hospital in time of peace is the contraction of *venereal disease.*

It is estimated that more than one million cases annually were treated in the French army, with an average loss of thirty-seven to fifty days of service, not to mention the pecuniary loss. In the garrison of Marseilles the annual average of venereal was reported to be 124 for every thousand men, or about 1 in 8. From 1862 to 1869, of 709,064 admissions there were 40,003 venereal cases, being 56 in the 1,000 and 106 for the 1,000 effective force; 10,000 days of sickness gave 1,900 for venereal diseases. In Algeria, in 1869, the proportion was 156 in the 1,000. In 1872, statistics indicate 91 in 1,000 for the army of the interior, and 137 in 1,000 for that of Algeria. The average for all the army was 1 in 10. In 1873 it was 88 in the 1,000. In the Belgian army the proportion of venereal is about the same as that of the French, one-tenth of the effective. The same proportion exists in the Portuguese army, where one finds 96 in the 1,000.

In the Prussian army there were, in the 1,000, in 1867, 54; in the Austrian (1869), 63; in the army of Holland (1868–69), 105; in the United States army (1883), 60 for the white and 66 for the negro troops. The proportion for 1884 gives 63 for the white and 81 for the black. The ratio is lower in the Prussian army for 1879 and 1880; but the vicennial rate for the English army in the United Kingdom gives a much higher figure.

The frequency of venereal in the English army is owing, in a measure, to the neglect of the prophylactic measures adopted by other countries. Figures show 329 cases for every thousand men, nearly 1 to 3, which is in contrast to the French figures of 1 to 10. It must be admitted, however, that the Contagious Diseases Act, wherever it has been enforced, has sensibly diminished the frequency of venereal diseases in the army.

It is thought by some that enforced celibacy is one of the circumstances that increase the mortality of the army. Others, in admitting the greater mortality among single than among married men of the same age, think the influence of celibacy to be greatly exaggerated, since many single men renounce marriage because of bad health or disease, a cause of celibacy that is not met with in the army, where there is an enforced celibacy analagous to that of priests, who, though single, live as long as married men.

Serious depression of the vital powers, known as *adynamia,* is one of the most common consequences of the soldier's mode of life, and it is this condition with the scorbutic taint that complicates his other diseases.

Scurvy has prevailed in armies from time immemorial. It would be the work of sterile erudition to catalogue a long list of scorbutic epidemics, but the history of the principal ones are full of instruction to the army surgeon. A passage from Pliny seems to relate to the prevalence of scurvy in the army of Cæsar Germanicus, which he says was healed with the *herba britannica.* Strabo also speaks of an analogous malady that occurred in the army of Ætius Gallus, in Arabia. But it is in the thirteenth century that we find epidemics of scurvy so well characterized in the armies of the Crusaders. In 1250, Louis the Holy was himself attacked with it, and the malady destroyed one-sixth of his army. The old navigators, Vasco de Gama and Cartier lost most of their crews from scurvy. In 1703 it destroyed 6,000 men in the garrison at Thorn. And so the history might be multiplied of epidemics occurring in fleets and armies, in besieged fortresses, and during campaigns down to the Crimean war, and even beyond. In that war the French army lost more men by scurvy than were killed by the enemy. Although the occurrence of scurvy is looked upon as a reproach to the medical officer serving with troops, it has lately prevailed in some garrisons in an endemic form. In the Russian army, in 1873, its prevalence is mentioned as 5.3 per cent.; in the Austrian army, 1870–73, 11, 8, 6, and 12 per cent. At Prague, in 1873, it was epidemic in an army of 7,500, and there occurred 169 cases, of which four died. The scorbutic taint, the writer is informed, exists in the United States army among troops serving in Arizona.

The principal cause of scurvy is defective alimentation. The want of fresh vegetable diet, poor water, the absence of milk and beer, damp, ill-ventilated quarters, debility, great exertion, and a uniform diet may be specifically enumerated.

The prevention of scurvy nowadays is too well understood to require much comment. The Nares expedition to the Arctic in 1875–76, suffered much from scurvy, which was attributed to the absence of lime-juice. Subsequent expeditions have done without lime-juice, and no case of scurvy has occurred. Two Arctic expeditions have convinced the writer of the antiscorbutic qualities of good beer and wine, used in moderation, and there appears to be a consensus of opinion among both executive and medical officers of late Arctic expeditions in regard to their judicious use; as may be gleaned from the *précis* of evidence taken by a Parliamentary Committee. Sir Edward Parry attributed the greatest antiscorbutic effect to beer; Dr. Coban says this is the opinion of all the authors he has read who spoke concerning beer in the Arctic regions; Dr. Barnes believes beer decidedly antiscorbutic and recommends that it should be given; Sir George

Nares says abstainers are no better off than others, as regards scurvy. Captain Markham says he would as soon take a man of temperate habits on an expedition as an abstainer; the two total abstainers of his sledge suffered severely, and he himself felt better after he took to drinking his rum. Sir L. McClintock says there is no advantage in teetotalers; Mr. Alexander Gray, that there is no advantage in point of health among abstainers on board whalers. Dr. Envall, who accompanied Nordenskiöld, condemns excess, but believes spirituous liquors to be of great use in small and moderate quantities. Nordenskiöld and Palander in 1873 took a sledging journey from their winter quarters in Spitzbergen, in lat. 79° 53′ north, and were away sixty-six days. There was no scurvy, though the party had no lime-juice. Their diet consisted of pemmican, biscuit, salt pork, butter, coffee in abundance, and a little spirits daily. All returned in excellent health. Comparison may be made between the Alert of the Nares expedition (on board which scurvy prevailed, notwithstanding the careful daily administration of lime-juice), and H.M.S. Assistance in 1850–51. In the Assistance there was beer brewed on board, while the Alert had no such advantage. No scurvy prevailed on board the former ship. Captain Markham, speaking of the prevention of scurvy in any future expedition wintering in high latitudes, says the dietetic causes may be reduced to a minimum by varying the diet with condensed milk, butter, eggs, beer and wine. He also observes in regard to the adequacy and completeness of outfit, that former expeditions had the means of brewing beer on board, while the Nares expedition had no such advantage.

The most common *complications of scurvy* are dysentery and diarrhœa. The malady may manifest itself by functional troubles only—general debility, muscular pains, *hemeralopia*, etc. In fact the latter is regarded as a mani festation of scurvy, and has often prevailed epidemically in armies. Our first knowledge of the epidemic prevalence of hemeralopia in armies goes back to 1756, when seventy soldiers at Montpellier, belonging to different regiments, were attacked with night-blindness. Epidemics were of almost yearly occurrence in the French army. In 1837–38–39 the garrisons of Metz and of Strasbourg were attacked, and during several years the epidemic reappeared at Verdun and at Strasbourg, affecting each year nearly a tenth of the garrison. In 1847 hemeralopia occurred at different stations in France at the same time as scurvy. In 1853 seventy soldiers of an infantry regiment at Wissembourg became hemeralopic, while two squadrons of cuirassiers garrisoned in the same town were spared. During the Crimean war, both French and English were attacked. Scurvy prevailed at the same time. After the capture of Sebastopol, the number of hemeralopics was so great in the French army that certain regiments could not furnish the number of men necessary to mount guard.

Many other epidemics among the French could be mentioned. The malady is not, however, common to that nationality. In 1819 50 soldiers of a Swiss regiment, garrisoned at Lyons, entered hospital for hemeralopia. In 1834, in two Prussian battalions at Ehrenbreitstein and Pfaffendorf, 138 men were attacked. The garrison at Lisbon also had an epidemic of hemeralopia in 1856. In New Mexico and Kansas, Hammond has noticed hemeralopia as a scorbutic accident, and it figures in the returns of the United States army for 1883 and 1884.

Besides the numerous army epidemics, hemeralopia has been observed epidemically among fleets. The French frigate Alceste had 75 men with hemeralopia. They presented signs of scurvy at the same time. Hemeralopia and scurvy occurred simultaneously on the U. S. ship Raritan in 1846. Other epidemics of hemeralopia in sailors have disappeared on getting fresh provisions in abundance.

So many facts assimilate scurvy and hemeralopia in an etiological point of view that an abundant and varied diet suggests itself at once as the best prophylactic. The epidemic at Lisbon disappeared as soon as the ration was increased. Change of barracks does no good; certain regiments having continued to furnish hemeralopics during several years, notwithstanding frequent changes of garrison.

Epidemics of acrodynia, of frequent occurrence in past years in European armies, and beriberi, frequently observed in the English army in India, are believed by many to be of scorbutic origin.

The frequency of *alcoholism* in the army is one of the commonest causes that encroach upon its usefulness. This frequency is rather badly shown by statistics, for the reason that the term includes many pathological conditions and their symptoms, which vary according to the quantity of drink and the intervals at which it is consumed. Drunkards in the army die of "chronic gastritis," cirrhosis of the liver, albuminuric nephritis, arterial atheroma, and are registered as having died of these diseases when in reality it should be alcoholism which has taken the most important part in the production of the disease. Alcoholism prevails more extensively in the English than in the French army. In 1869 the mortality in the French army was 0.016 in the 1,000; in 1872, 0.027 in 1,000 by drunkenness and delirium tremens. In the English army from 1859 to 1866, 3,194 men were entered in hospital for drunkenness and 817 for delirium tremens, giving a proportion for the eight years of 6.4 in 1,000 men. In the same period there were 3 deaths by drunkenness and 50 from delirium tremens; being 80 from acute alcoholism and 0.13 deaths in the 1,000, a figure nearly ten times greater than that of the French army. In the colonies the mortality from alcoholism in the English army is much greater than that in the army at home. In the United States army for the year 1884 the number reported is 76 in the 1,000 for the white, and 4 for the negro troops. The observation of an experienced American officer is that the alcohol habit is rarely acquired by soldiers after entering the army; the habit in most instances being a confirmed one previously to enlistment.

It is rare that acute alcoholic poisoning terminates life. Cerebral hæmorrhage and pulmonary congestion have been known to terminate fatally while under the influence of drink, but the subacute form is usually manifested in gastric disturbances, delirium tremens, epileptiform convulsions, insomnia, hallucinations, etc. Chronic alcoholism imprints a particular character of gravity on all the diseases of drunkards. Its disastrous influence is seen not only in the prolonged congestions and the fatty and connective-tissue degenerations of various organs, but in general paralysis, mental alienation, and suicide. Alcoholism is one of the most frequent causes of insanity and suicide in the army. Some writers attribute to alcoholism nearly two-thirds of the mental diseases; it is said to be the principal cause of suicide in England, Germany, and Russia.

In the English army for the period of 1859 to 1866 the figure for suicides is 0.26 in the 1,000; for 1873 it is 0.25. The lunacy figures for the former period show 1.68 in the 1,000. These figures are lower than those of the French army. For the same period the annual loss by suicide rose to 0.27 in the 1,000; from mental alienation, 0.20 in the 1,000. From 1864 to 1869 there were 921 cases of alienation, giving a proportion of 1.31 among officers and 0.34 among men. In 1873 it was 0.38. In 1869 the number of deranged was 0.39 in the 1,000, and the suicides rose to 0.42 in the 1,000. In 1872 the proportion was 0.50 in the 1,000.

In 1873 there were but 13 suicides in the Italian army.

In the Prussian army from 1846 to 1863 the suicides were 0.46; from 1867 to 1872, 0.06. There were 30 suicides during the Franco-Prussian war. The average in the Saxon army corps is 0.92.

Statistics of the Austrian army for 1870 place suicides at 0.97, and give 15 per cent. to attempts. There were also 26 self-mutilations; 70 per cent. were from shooting, 21 from hanging. Suicides were four times more frequent in the non-commissioned officers than in privates. Self-mutilation occurred in privates only. From 1871 to 1873 the number of suicides was somewhat smaller, being 0.81. Among 361 cases the cause was unknown in 290; in 37 it was fear of punishment; in 12 melancholia; 4

each from hatred of the service and disappointed love. Twenty-three self-mutilations in 1873 involved the index-finger, middle-finger, and thumb.

Suicides in the United States army have been quite common in late years. The annual report for the year 1883 gives 17 suicides in an effective of 23,304. Of these 10 were from shooting, 1 from hanging, 2 from throat-cut, and 4 from poisoning.

For the year 1884 the same number (17) is reported out of an effective of 25,339.

Diseases influencing the operations of war are not limited to men. Horned cattle, horses, mules, camels, and elephants are subject to sicknesses that cause a great deal of inefficiency. In India serious inconvenience and delay are often caused in marches and transportations by sick elephants; disease in draught-animals affects military operations seriously, and often impedes strategy by delay in bringing up camp-equipage, munitions, and the like; diseases of horses influence the number of regiments of cavalry and field artillery, and when proper attention cannot be paid to the animals during a severe campaign, they may be seized with an epizoöty, or they may sicken and die by hundreds. Napoleon's campaign in 1813 was seriously affected by the deplorable condition of his horses, and cavalry and artillery animals perished in such numbers in the Crimea that batteries were practically unhorsed, and but few men could be mounted. The history of all campaigns will show that this cause has more or less impeded the operations of warfare; that bovine pest and war maintain almost constant relations; and that armies are the most active purveyors of cattle plague. A repetition of what has prevailed in all war times occurred in 1870. A few infected cattle of the Prussian army, having by mischance fallen into French hands, propagated disease to such an extent that the agricultural losses in France for that year were more than 100,000 head of cattle.

Knowing the interactions between each other of warfare and disease, the more calm, reflective, and self-reliant modern mind recognizes the necessity, both moral and political, for preserving the physical condition of the public servants who expose their life and health to the hazards of war, and to climates even more deadly.

Army and navy sanitation is constantly and rapidly improving; but it is yet far behind the advance of the nineteenth century, notwithstanding the foresight of those who endeavor to abolish or limit certain insanitary conditions incident to war. Do what we may, some of these conditions must prevail as long as armies and fleets exist, and the Angel of Death will direct the strategy of campaigns in spite of our best efforts. *Irving C. Rosse.*

ARMY FIELD HOSPITAL ORGANIZATION.—The Field Hospital Organization of the Army is the result of an evolution from simple elements by which provision is made for the proper care and treatment of the troops engaged in actual warfare. It may be best studied by following its progress from the elementary conditions under which one medical officer discharges the whole of the field duties, to the fully developed organization, in which each medical officer in the command performs a certain duty as a part of the machine. The history of our army during the past twenty years furnishes many illustrations of the elementary forms, as necessitated by the conditions of Indian warfare; while the history of our armies during the war of the rebellion gives many admirable examples of the fully developed organization.

When a detachment of troops, numbering from fifty to one hundred and fifty men, takes the field, it is accompanied by a medical officer. Before starting on the expedition this medical officer duly considers its probable issues as affecting the well-being of the men engaged, and makes suitable provision for their occurrence, so far as can be done with existing facilities, or under existing restrictions. From the supplies of his hospital he selects such medicines, instruments, dressings, stimulants, and other medical comforts as may seem necessary. If the military operations are to be conducted in a difficult mountain country these hospital supplies are packed on mule-back; but if the roads are passable to wheeled vehicles, an ambulance wagon accompanies the expedition for the transportation of sick or wounded men, while stores and hospital canvas are carried in one of the heavier wagons. So long as the command is free from serious cases of sickness or injury, the only man specially belonging to the hospital department may be the driver of the ambulance, but when their services are necessary, one or more men are detailed for duty, under the orders of the medical officer, to attend specially to the wants of the patients.

On the march this ambulance wagon follows closely in the rear of the column of troops, constituting an ambulant or travelling hospital. When camp is reached the medical officer selects a suitable site for his hospital tent, to which his patients are transferred, and in which they are fed and otherwise cared for by the men detailed under his direction. If casualties occur from an engagement with the enemy, the medical officer gives such aid to the wounded as is possible on the field, and superintends their removal to the hospital, the ambulance wagon or stretcher being used for their transportation, according to the distance or to the nature of the injuries sustained in individual cases. At the hospital the needful surgical assistance is rendered and the wounded are treated, until facilities are afforded for their transfer to some permanent military post. But the military conditions necessitating advance or retreat, may call for the removal of the wounded from the field hospital at the earliest possible moment, in which case certain of the supply wagons which have been emptied during the progress of the march or campaign, may be utilized for their transportation with the command, until an opportunity is afforded of transporting them to a permanent establishment.

If the command is larger, consisting of several hundred men, provision is necessarily made for a larger number of sick and wounded. The surgeon is accompanied by one or more assistants, and by a hospital steward in charge of the supplies. The hospital train consists of two or three ambulances and a heavy wagon containing the supplies, tents, stretchers, hair mattresses, blankets, and a special outfit for the hospital kitchen. Before starting on the expedition details are made for hospital duty, as for stretcher-bearers, cooks, and nurses. The surgeon exercises general supervision, acting as medical officer on the staff of the commander, or, in other words, as health officer of the command. The senior assistant has charge of the ambulant hospital; the junior keeps the records and carries out special instructions in individual cases.

Such a body of men as has been mentioned is practically a regiment. Officially the regiment consists of ten or twelve companies, each mustering from fifty to a hundred men. A surgeon and two assistants are usually assigned to duty with it. The Regulations of the United States Army provide it with three ambulance wagons if there are five hundred men or more in the ranks, and with one transport wagon for tents, medicines, stores, and other necessary material. The *personnel* of the hospital train consists of a driver for each wagon, two stretcher-bearers attached to each ambulance, and a sergeant in charge, in all eleven men; while that of the hospital proper consists of a hospital steward in charge of the supplies, two cooks, and nurses in the proportion of one to each company.

Whether the expeditionary force consists of a small detachment with one medical officer, a regiment with several medical officers, and the hospital train and outfit as described, or of a hundred such regiments, the duties required of the medical department are identical. The senior medical officer must make necessary provision for all probable contingencies; or, if unable to do this, he must make known his requirements to the proper authorities. Requisition must be made for the medicines, stores, and appliances which may be needed, including the ambulances and supply wagons. The sick and wounded men must be carried during the march, and must have their wants attended to with as much care as if they were in a stationary and permanent hospital. In temporary camps they must be similarly cared for in the hospital shelters. If the command is threatened with epi-

demic disease, the necessary measures must be enforced to prevent its invasion or spread. Should an engagement take place, the wounded must receive needful aid on the field, and must thereafter be transferred without delay to the field hospital, where primary operations are performed prior to their removal to some more permanent depôt.

With a detachment in the field, the one medical officer has to perform all the duties of his department; but with a regiment these duties are shared by the several medical officers forming the staff. The regiment is the unit of organization for masses of men, from the military point of view; but it does not afford a broad enough basis for the establishment of a competent field hospital organization. This will be appreciated readily if a number of regiments are assumed to be aggregated in the same camp. On the regimental basis there are as many small hospitals as there are regiments. The sick men of each regiment are treated in their own hospital by their own medical officers. So far this is satisfactory, and if these commands were in a permanent camp and free from epidemic disease, there is no argument worthy of special notice against the existence of the regimental hospitals. But these regiments are assumed to be in camp for field service, and as soon as the orders to march are published, the inaptitude of these hospitals to meet the new conditions becomes manifest. Military policy dictates that the column of troops on the march should be a column of fighting men, unbroken, at the regimental intervals, by ambulances carrying sick men and by wagons with medical or other supplies. The ambulances with the sick are, therefore, aggregated into a single train, with position in rear of the last regiment, forming practically a general ambulant hospital for the command. The wagons containing the tents and hospital stores form part of the general supply train, which follows the command under the protection of the rear-guard. On arriving at the site selected as the camp-ground for the night, the ambulances which have travelled as an aggregate hospital during the day, become separated into their regimental elements, each camping in the vicinity of its own command; and as the regiments may be widely scattered, many of them at considerable distances from the direct line of march, the day's march for the sick man may be thus needlessly lengthened. The troops, who carry their shelter-tents and rations with them, are able to make themselves comfortable as soon as the camping-ground is reached, but the hospital attendants must await the arrival of the rear-guard and wagon train before they can place the tired and suffering sick under shelter and refresh them with appropriate nourishment. Delays of this kind are especially frequent in wet and inclement weather, when the condition of the roads impedes the progress of the supply train.

But it is chiefly during and after a battle that the incompetency of the regimental system of hospital organization is manifested. The hospitals are scattered at various distances from each other along the rear of the line held by the troops. They are inconspicuous, and not easily reached by such wounded as come rearward without assistance or guide. No satisfactory supervision can be exercised over them. Some of the regiments suffer more than others. Their ambulances and stretcher-bearers are unable to remove the wounded with promptitude from their exposed position in the field. The medical officers are overworked, yet cannot accomplish all that should be done. Their hospital shelters are insufficient, and their supplies perhaps inadequate. Meanwhile the medical officers of those regiments that have not become engaged, or have not suffered severely, are at their posts awaiting the unknown developments on the line of battle. If there seem to be no prospect of an immediate call to action, these officers may assist their overworked comrades; but they may show some hesitancy in sharing their stores and dressings with others, if there is a likelihood of their own commands becoming engaged before opportunity is afforded of replenishing these at a purveying depôt. In fact, a regiment may at any time have more wounded men than can be provided for within the limits of a regimental hospital.

For purposes of command on active service regiments are brigaded. Four or five regiments constitute a brigade, which is under the command of a general officer. The brigade forms a more appropriate unit for field-hospital organization than the regiment. The senior surgeon exercises general supervision, and advises the commanding general on all matters pertaining to the health of the troops. The hospital train is, subject to his orders, under the command of a second lieutenant detailed from one of the regiments as ambulance officer. The surgeon is thus relieved of the responsibility for property which attaches to the possession of wagons, horses, and harness, for his ambulance officer acts as quartermaster of the hospital. The train consists of fifteen ambulances, on the assumption that the brigade is formed of five regiments, each numbering over five hundred men, a light medicine wagon, and some heavy transport wagons carrying the hospital canvas, bedding, and stores.

When the line of march is taken up, the ambulances, accompanied by the medicine wagon and one or more wagons containing a part of the hospital outfit, accompany the troops. Wagons carrying forage, rations, and other supplies not immediately required, travel with and form part of the general supply train. Two medical officers are placed on duty with this ambulant hospital, which is not broken up on reaching camp, but preserves its organization under canvas as on the march. Standing orders assign the various regimental officers to specific duties in the event of a battle. These are issued on the recommendation of the brigade-surgeon. One surgeon is assigned to duty as the operator for the command; three medical officers are detailed as his assistants; the others remain on the field with their regiments. As soon as the position of the line of battle is determined the brigade-surgeon selects the site for the hospital, which is immediately established, while the ambulances and stretcher-bearers proceed to the front to bring in the wounded. Thus, though but one regiment may suffer, the medical strength of the brigade contributes to the care of its wounded. The medical officers detailed to accompany the regiments in the field select the nearest point to the line of battle where some shelter from infantry fire may be obtained. The nature of the ground often renders it advisable for the medical officers of several regiments to aggregate at one point, to which the wounded are assisted or borne upon stretchers; but although there may be a large accumulation of wounded at such a point, it is never recognized as a field hospital, but as an ambulance depôt, to which wagons repair for the conveyance of the sufferers from the field of danger. Water-supplies and stimulants are to be found at these depôts, and much minor surgery is performed. Clothing and bullets are extracted from wounds, hæmorrhage checked by styptics, torsion, or ligatures, and water or other simple dressings applied, according to the character of the injury and the time which the surgeons have at command between the arrival of the cases and their departure by wagon for the hospital, where the operating staff of the brigade is at work.

It is, however, inadvisable, for military reasons, to have the marching column of a large army broken up at brigade intervals by hospital trains. Hence follows a further consolidation or higher organization. Several brigades united for purposes of command constitute a division. A surgeon-in-chief or medical director on the staff of the commanding general has control of its medical department, which consists of the regimental medical officers, stewards, and detailed men, and of the brigade ambulance trains, consolidated under the command of a first lieutenant of the line.

A medical officer is detailed as surgeon in charge of the hospital of the division, and assistants are assigned to him, usually one from each of the brigades. He is responsible for the care of the sick on the march and in camp, and for the comfort and general welfare of the wounded when brought to his establishment by the ambulance corps. A man of indomitable energy is required for this position, one who is quick to see and prompt to act, for the time

in which action is possible is usually limited. Under favorable circumstances a few hours may be obtained before the wounded begin to come in, and much preparatory work may and must be done during that time. But frequently the first cases reach the hospital site before the kitchen fires are well lighted or the shelters prepared. Everything has to be accomplished while the patients are arriving, and the work of perfecting the hospital continues to the last hour of their stay. An operator and assistants from each brigade constitute the surgical staff of each section of the hospital. Under the ordinary conditions of camp life these officers perform their regimental duties, acting as sanitary officials, and attending professionally to such cases of sickness as may be treated satisfactorily in quarters; but when an engagement is imminent they report at the hospital for duty at the operating-tables.

The Regulations of the United States Army prescribe, as has been stated, the number of ambulances that may be attached to a command, and the number of men that accompany them as drivers and litter-carriers. A division of ten thousand men, organized into three brigades, each consisting of five regiments, is entitled to a train of forty-five ambulances, commanded by one senior and three junior subalterns, and manned by fifteen mounted sergeants, forty-five drivers, and ninety stretcher-carriers. Besides these there are three medicine-wagons specially fitted for the field-hospital service, heavy baggage-wagons for tents, bedding, rations, and forage, and a travelling-forge for horseshoeing and field repairs for the train.

But although the legal allowance is thus specified, it by no means follows that the command will always be fortunate enough to be provided with that allowance. It is of interest, therefore, to consider what amount of transportation and supplies is imperative for efficient work under the ordinary conditions of the battle-field. Assuredly there ought to be enough of field supplies on hand to keep the surgical staff at work during and after an engagement, and as certainly the means of transportation for the wounded ought to be such that the operator will not have to wait for his next case to be brought in from the field after the engagement has begun. There is thus a minimum of transportation and supplies based upon the working powers of the surgical staff. But the scope of the hospital and ambulance work includes much more than operative surgery. The response given under favorable circumstances by the surgeon in charge of a field-hospital to an inquiry concerning the progress of his work during an engagement would probably be as follows: "We are doing very well: we have removed our wounded from the field, have fed them and made them comfortable, and the operative work is progressing." These phrases, in their order of sequence, represent the practical view to be taken of the duty of the field-hospital toward those who have fallen. They must be removed from the field without delay, for delay is exposure to further wounding; it is unnecessary suffering from weather inclemencies, mental agitation, shock, hæmorrhage, and pain, which, if not leading directly to a fatal issue, may be the cause of tedious convalescence and future disability. The first consideration is their removal, and the means to effect this must be proportioned to the probable casualties and irrespective of operative proceedings at the hospital. As the probable casualties are dependent on the number of men in the ranks, there is thus a maximum of transportation, presumably the regulation allowance, based upon the size of the command.

The absolute loss sustained in an engagement is proportioned to the number of men engaged. But as in a division one brigade will suffer more than another brigade, and one regiment be more severely handled than another, it follows that the maximum loss expressed as a proportion of the men engaged will be smaller in a large than in a small command. The probable casualties in every hundred men of a division will be represented by a smaller number than will represent the probable casualties in every hundred men of a brigade. Companies may be destroyed, regiments may lose half their number, brigades be decimated; but, unfortunately, we do not know, as facts from the history of our armies, what have been the maxima of battle losses suffered by commands of various strengths. The records of the war of the rebellion, so far as published, do not furnish the necessary data.

As it is impossible to determine with certainty the maximum casualties that may occur in a division of ten thousand men, the greater interest attaches to the consideration of that minimum of transportation and supplies which is based upon the working powers of the surgical staff. This working power is a vague and uncertain measure. It cannot be expressed in definite terms like the power of a steam-engine. It varies in different individuals, and at different times in the same individual, according as the surrounding conditions assist or impede. But with all these difficulties, when a certain amount of operative work is definitely stated, there need be no hesitation in concluding whether it can or cannot be accomplished in the given time by earnest men in possession of their normal health, strength, and endurance. But the estimate as to the possibilities must be made by one who has seen veterans in field surgery at work against time, with the inexorable military necessity requiring the hospital to be emptied by a certain hour, and humanity, and perhaps the professional spirit urging them to the completion of their task. The capital operation—the amputation or resection—requires but a short time for its performance. The systematic division of labor under the supervision of the surgeon in charge relieves the operator of his case as soon as the last roller is adjusted or dressing applied, and furnishes its successor for consideration and operation if necessary. Time lost in field surgery is lost between cases, for want of that active and systematic direction which enables all to be constantly employed.

At first sight, the uncertainty as to the amount of surgical work implied by the presence of a certain number of wounded would seem to render it impossible for an expression to be given of the ability of the operating staff to accomplish it. Wounds vary in degree from the simple lesion of the superficial or muscular tissues, to penetration of cavities with visceral injury and fractures of bones, with implication of important vessels and nerves. Individually they require more or less attention, from the simple dressing which may be applied by the patient himself to the capital operation under anæsthetics, or the application of some form of apparatus to secure immobility. But by examining the statistics of war surgery, the probable amount of work which a given number of wounded will bring to a hospital may be ascertained.

In every hundred of wounded, as shown by an appended table compiled from the "Surgical History of the War of the Rebellion," there was found to be a necessity for:

	Cases.
Primary amputation or resection in fractures of the larger bones and joints of the upper extremities in	2.78
Amputation or resection in fractures of the larger bones and joints of the lower extremities in	3.22
Amputation or resection in fractures of the hand in	2.07
Amputation or resection in fractures of the foot in	.30
Ligation of arteries, removal of ball and bone splinters, partial excisions, formal trephinings, and other operations in injuries of the head, neck, and trunk, and in flesh wounds of the extremities in	1.00
Application of dressings to secure immobility in fractures of the long bones and larger joints of the upper extremities in	6.01
Application of dressings to secure immobility in fractures of the long bones and larger joints of the lower extremities in	5.51
Making the percentage of wounds requiring special attention at the operating-table of the field-hospital	20.89

This accounts for 20.89 of the hundred; the remainder consisted of flesh wounds (many of which had already been attended to at the ambulance depôts), calling only for simple dressings or the occasional use of the pocket-case; of fractures of the hand and foot which, requiring no operation, seldom involved a necessity for special dressings to secure immobility; and of those grave cases of injury to the head, chest, and abdomen, in which the resources of the surgeon are unfortunately limited. The care of these, although constituting surgical work, must usually in these emergencies be delegated to skilled

Army Hospitals.

nurses, dressers, and attendants doing duty under the supervision of the medical staff. Some of these cases, however, make notable calls on the time of the surgical staff for consideration, if not for operation; but as regards time spent in consideration, it must be remembered that there is a laxity in the rules for operative interference which enables the surgeons to work on cases in which the indications are manifest, while the others receive the benefit of the conservative doubt.

Many circumstances may occur during a campaign to diminish the capacity of the surgical staff for work. Deficient rations, the fatigues of the march or of previous engagements, deprivation of sleep, and weather exposures, may have induced a condition of depressed vitality, which will manifest itself in their actions, notwithstanding their efforts to overcome it under the stimulus of present battle and urgent professional calls. Hence, although the work which is implied by the presence of a certain number of wounded may be known, no line can be drawn or standard raised by which the operations of a hospital may be measured in particular instances. Nor is this sought to be attained. The object in view is to realize the work which may be done, under the most favorable conditions, that the operating staff may not have its capacity for work rendered valueless to the wounded for want of the needful supplies and transportation.

The experienced field-surgeon will readily allow that, if the operating staff of a division hospital consisting of three brigade sections is properly supported by trained nurses and attendants, five hundred men may be received into hospital and put in condition for removal therefrom, if necessary, by the end of forty-eight hours, without making an undue strain upon the energies of the establishment. When a thousand men are received, the necessity for unusual effort becomes apparent; but the effort is not so much the result of doubtful ability to attend to this number as of fear lest there be more to come. If more do come, making a total of twelve or fifteen hundred, the working power of the staff is undoubtedly exceeded, but with such numbers come conditions which strengthen the powers of the hospital.

The ratio of killed and wounded varies considerably in different engagements, and especially if the casualties in small constituent parts of the army are made the basis of the calculation; but the rate obtained from the summary of engagements and battles in the "Surgical History of the War of the Rebellion" may be accepted as indicating the probabilities:

	Killed.	Wounded.
United States troops	59,860	280,040
Confederate troops	51,425	227,871
	111,285	507,911

This corresponds to one man killed for every 4.564 wounded; or, in percentage of casualties, killed, 17.97, wounded, 82.03.

For a division of ten thousand men to have a list of wounded numbering from twelve to fifteen hundred implies a loss to it in killed and wounded, and to the army of which it is a part, which ordinarily involves days of recuperation before the struggle can be renewed. This lengthens the existence of the hospital, giving an extra day or two to complete the primary operations, and permitting medical men, hitherto on duty at ambulance depôts on the field, to reinforce the hospital staff and hasten the completion of the work.

The experience of the past shows that if the division hospital is thoroughly prepared to give the needful primary attention to twelve hundred wounded, the history of its service will not fail to give satisfaction. All ordinary and probable occasions will be provided for, and, if the extraordinary and unlikely should occur, the circumstances which attend them may be susceptible of being turned to account in the interest of the wounded.

On a basis of this kind the minimum of necessary medicines and surgical supplies can be approximated; but as these do not make a large demand upon the transportation, this minimum should be appreciated only to be exceeded. In so many hours after a battle the field-hospital should be in a condition to move with the army for further operations, although there may have been no communication with medical purveying depôts in the meantime. The scope of this essay does not include tabular lists of supplies.

On this same basis the maximum of food supplies which it is advisable to carry can be calculated. Provision has to be made only for the emergency, for the first twenty-four hours after an engagement. By the end of that time, if the troops have held their ground, wagons from the general supply train will have been distributing rations, and the hospitals will participate in the distribution; or, if the troops have been driven back, leaving the hospitals without their lines, food supplies must be obtained from the other side by flag of truce or by foraging. Rations, consisting of tea and coffee, sugar, hard bread, and beef-essence, must be carried, and sacredly preserved for the wounded during and after an engagement. These will support the hospital until the arrival of the supply-wagons, even should there be some delay; for not all of the wounded borne upon the hospital registers draw on its food supply during the first hours. Many of the slighter cases camp or bivouac in squads under the flag of the medical department, and supply themselves from the contents of their haversacks after a cup of coffee or basin of soup from the hospital kitchen on their arrival; and the demand for food by the severely wounded is not great.

The supply of underclothing, of bedding, and of canvas for shelter is not measured by the total number of casualties in a given battle, but by the number of cases of severe wounds. This number includes nearly twenty-one per cent. of the total of twelve hundred wounded men; hence, if underclothing, stretchers, cots, or light bedsteads, mattresses, blankets, and hospital-tent accommodation are carried for two hundred and fifty patients, the severely wounded will be provided for under all but exceptional conditions. To extemporize couches for the slighter cases when the total number exceeds two hundred and fifty, a supply of bed-sacks, which are light and occupy but little space in the wagons, should be provided.

To determine the amount of wheeled transportation which will insure the speedy removal of the wounded from the field, consideration must be given to the character of the injuries. Many men with flesh-wounds, and even with fractures of the upper extremity, find their way to the hospital unaided. Others bear the transit easily in the sitting position, and an ambulance can carry six, seven, or more such cases per trip, according to its plan and construction. But a certain proportion of the wounded require transportation in the recumbent position, which, in some distressing instances, must be effected by the stretcher-bearers. The wagons, when laden with such cases, can carry but three per journey, two severe cases within and one of less gravity on the seat with the driver.

An examination of the table appended to this article will furnish an approximation to the number requiring special care in their transportation. These may be summarized as follows per hundred wounded:

Fractures of the skull	1.77
Fractures of the vertebræ	.26
Wounds penetrating the chest	3.55
Wounds penetrating the abdomen	1.50
Fractures of the pelvis	1.28
Fractures of the lower extremity, excluding those cases of injury to the foot which do not require operation	9.01
Percentage of cases requiring the recumbent position	17.37

In this estimate cases of severe shock attending injuries other than those tabulated, and of extensive flesh-wounds which prohibit the sitting posture, are not included, as they may be considered offset in part by those wounds of the lower extremity, as of the ankle, which do not imperatively demand recumbency during the journey. If those who require special care in their transportation be put at twenty per cent. of the whole, thirty wagons, with their attendant stretcher-bearers, will, in four or five hours, be able to accomplish the work implied by a loss in wounded of twelve hundred men, provided no unusual difficulty is experienced in aggregating the sufferers at

the depôts, and that the hospital is established within a proper distance of the line of battle. The number of those who reach the hospital without assistance is always large, but it is relatively larger after severe engagements, for, when the depôts are crowded with men awaiting transportation, many will undertake the journey on foot, rather than wait so near the area of danger for the return of the wagons. Each ambulance wagon should be provided with a keg of water and a locked box for the surgical supplies and food to be mentioned hereafter; an axe, two stretchers, a lantern and candles, and an iron pail, which can be used in case of need as a camp-kettle, complete its field equipment.

These ambulance wagons should be used but seldom for the removal of the wounded on the breaking up of the field hospital, and only when they can return in time to secure a few hours' rest before the order to march has to be carried out. They are a formal part of the field hospital, and ought not to be separated from it without a thorough knowledge of the military contingencies probable during their absence, or an order from superior authority, which is equivalent to such knowledge. Usually the wagon-trains of the supply departments, after unloading at the front, may be secured for the removal of the wounded to the base, where accommodations for their treatment or special means of transportation to other points have been provided. If more wagons are required than have been furnished by the departments, an effort should be made to obtain them by further issues to the troops.

The train of the division field-hospital includes, in addition to the thirty or more ambulances, their complement of men and their travelling-forge,

First:—Three medical hospital wagons, one for each brigade section of the hospital, specially fitted for the transportation of the supply of medicines considered necessary for the campaign, as well as for the greater portion of the surgical supplies, including stimulants, anæsthetics, morphia, dressings, and instruments, with the operating-tables and tent-flies to be pitched over them, in case the weather should require this shelter for the patients and operators. In addition to the driver, each of these wagons has attached to it, travelling always with it and in special charge of its valuable contents, an hospital steward or apothecary, who dispenses under the rules instituted by the surgeon in charge, and who, during action, supplies the dressings and stimulants and looks to the safety of the uncased instruments. This steward is also responsible that the locked boxes of certain of the ambulance wagons are stocked with an assortment of surgical supplies, such as chloroform, whiskey, morphine, lint, rollers, and plaster, and that the boxes of the ambulances not so stocked are stored with beef-essence, tea, sugar, and hard bread. The ambulance officers, as well as the steward and surgeon in charge, are aware of the kind of special supplies in each ambulance, and details of the wagons are made from this point of view when required on particular occasions. By this arrangement field supplies and stores are found by the side of the wounded as soon as they are brought from the field, although the character of the roads or other accidental conditions may have temporarily delayed the arrival of the heavier wagons; and the special work of the operating-table and kitchen can progress on this preliminary supply until the adverse conditions are overcome and the medical and other wagons have reached the scene of action.

Second:—Ten or more heavy wagons, the number depending on their capacity and construction, intended for the transportation of—

(*a*) Hospital canvas for the shelter of two hundred and fifty patients, including the necessary poles and pegs, and the axes, picks, shovels, and other tools requisite for pitching the tents and trenching the ground around them.

(*b*) The wall-tents and personal baggage (limited) of the officers, and the shelter-tents, blankets, and knapsacks of the men of the command.

(*c*) Strong but light stretchers, similar to those carried on the ambulances, to be used as field bedsteads, light mattresses, a stock of blankets and underclothing, and of bed-sacks, which, when required for use, may be filled with hay or other available material.

(*d*) The ordinary army ration for the men of the command for the number of days which will elapse before new issues are made from the base or general supply train, together with the requisite kitchen outfit.

(*e*) Rations of bread and beef-stock, tea, sugar, coffee, salt, etc., for twelve hundred men for one day, with camp-kettles and a small supply of plates, mugs, spoons, etc. These are carried for use in case of an engagement, to insure food supplies to the wounded until communication is opened with the supply trains after the battle. When this communication is effected these stores should be immediately replaced by requisition on the proper officer of the subsistence department.

The ambulance officer is responsible for the property included in the train, and by frequent inspections and timely requisitions and repairs, preserves it in a state of thorough efficiency. He is necessarily a mounted officer, as his duties involve rapid transit from one point to another. He institutes drills in his command, and instructs his drivers and stretcher-bearers in the best and most expeditious manner of handling the sick and wounded. He superintends the removal of the wounded from the field, their aggregation at the depôts, and their transmission to the hospital, and satisfies himself by personal inspection of the field that his men have accomplished their work. He familiarizes himself with the country between the line of battle and the hospital, instructs the drivers as to the shortest and easiest routes, and, if need be and it is possible, arranges for improving their condition.

On the breaking up of the hospital he superintends the arrival and departure of the wagons, to avoid unnecessary delay from carelessness or the misunderstanding of instructions. He acts as subsistence officer and quartermaster of the hospital, so far as concerns its regular rations of food and forage, and its issues of clothing, when such are required; but with the accommodation, medical stores, and other property pertaining specially to the wards he has no connection, other than as master of the transportation, to see that they are on the ground and available when required.

Three subaltern officers aid the ambulance chief in his duties, and take command of detached portions of the train when the accident or duty of the time necessitates their detachment. They should be active and enterprising men, well versed in field-work, and capable of assuming charge of the whole train and its responsibilities in the absence of their superior. Each officer and man connected with the hospital and its train should be familiar with his duties under the various conditions of the camp, the march, and the battle-field, that there may be no confusion, loss of time, or wasted energies when the period of action unexpectedly arrives. There is a certain amount of work to be done, and it can be accomplished in many cases, if at all, only by each individual having a thorough knowledge of his own share and doing it satisfactorily. Drill gives perfection in action to the results of disciplinary methods; but the true drill for the field hospital is only to be found in active service. There is, fortunately, in most campaigns, a preparatory period of marching and camping before the opposing forces commence their struggle. During this period the regularly recurring establishment of the hospital at the end of the day's march for the care of the casual sick, gives that familiarity with practical details which enables the *personnel* to accept the results of battle as a simple exaggeration of ordinary and daily duties.

If the division is operating as an independent command the hospital follows the rear of the marching column; but if it is a part of a larger command the order of march may direct a temporary partition of the hospital train. It may be imperative, from a military point of view, to have the various divisions of the army well closed up and unbroken by baggage or other heavy wagons. The ambulances and medicine wagon are then permitted to follow in rear of the command to which they belong; while

Army Hospitals.

the heavier transport wagons of the hospital fall into position with the regimental baggage, ordnance, subsistence and forage wagons, in rear of the whole fighting force except the rear-guard, or the command specially detailed for their protection. In this column the hospital wagons are generally accorded the lead. One of the ambulance officers is assigned to duty with the portion of the train thus detached. This separation is usually temporary, the completion of the day's march bringing the wagons into camp shortly after the troops and their ambulances have reached it, the time of their arrival depending on the length of the marching column and the character of the roads, the weather, etc. Occasionally, however, the conditions of the campaign may continue the detachment of these wagons for a longer period.

On the march the ambulances and medicine wagons constitute the division field-hospital. Following in rear of the troops, it picks up those who have fallen out of the column from accident or the development of disease. Usually each of these men has been examined by his regimental medical officer and furnished with a card of authorization to await the passage of the ambulances. One of the officers on duty with the ambulances receives the cards, admits the patients, and procures from the medicine wagon such articles as may be needful for their immediate treatment. This admission by card may seem, to those who have had no field experience, to be a piece of what is known as official red-tape ; but it is needful to save the energies of the hospital surgeons and preserve the ambulance transportation for the more urgent cases. The regimental officer knows the men of his command, and can arrive at an accurate estimation of the conditions in a given case in less time than the hospital surgeons, who have no previous knowledge, and who must conduct their examinations while on the move. If the troops are raw and undisciplined, men may drop out of the ranks in large numbers without the sanction of the regimental surgeons, and besiege the ambulances for admission. There is no time, while being pushed forward by the troops in rear, to make a discriminating examination, and these applicants are permitted to enter the ambulances. At the next halt for rest a few of the unwarranted entries may be weeded out, if the time of the officers is not wholly occupied in examining other candidates for admission ; but ultimately, if the march is long, the roads bad, or the weather oppressive, every seat is in use, and the surgeons are importuned for the accommodation which they can furnish only by discriminating between one fagged-out man and another. The preliminary examination by the regimental surgeon, and admission to hospital on his authority, prevent this strain on the energies of the ambulant hospital.

The march has its sufferers as well as the battle-field, and these must be carried along and cared for ; but simple exhaustion must be met by the general principle of halting the column at intervals for rest. If the military necessity requires a forced march, the commanding general must accept the loss of men which his line will suffer as the price of the position which he secures. The ambulances are an hospital, not a means of transportation for a jaded army. The sick and injured are to be carried, not the merely exhausted, who, by a short period of rest will be recruited and enabled to push forward to the end of their march.

At the conclusion of the day's journey, when not immediately in front of the enemy, the hospital camps in some suitable place in rear and not distant from the command. While awaiting the arrival of the baggage wagons the sick are examined and treated. Such as are considered fit for duty are directed to report to their regiments. A notification should be sent to regimental surgeons in the cases of men admitted during the march without their knowledge, and retained as unfit for duty at its conclusion, that these men may be accounted for on the regimental reports. In the meantime the surgeon in charge indicates to the hospital attendants who have been detailed as pioneers, the position which he desires the tents to occupy. Wood and water are procured, and the kitchen, and such other fires as the season and climate may require, are lighted in front of the position to be occupied by the tents.

In the temporary camp of an active campaign the wood-fire, a few feet distant from the open front of the tent, is the simplest and best means of warming its interior. If a strong wind is blowing care must be exercised in the selection of their relative positions.

On the arrival of the heavy wagons, the pioneers unload and pitch as much of the hospital canvas as may be required for the accommodation of the sick, and subsequently the tents of the officers. The nurses unload and fit into the raised canvas such stretcher-bedsteads, bedding, and other articles as may be necessary, and thereafter the stretcher-bearers transfer the sick from the ambulance wagons.

The cooks obtain their kitchen utensils, and furnish tea and coffee by the time the sick are in their cots. Later in the evening dinner is prepared. Pending the preparation of this meal the ambulances and wagons are packed in rear of the tents and the horses fed, watered, and groomed, while the stretcher-bearers pitch their shelters between the wagon park and the hospital tents, and the pioneers trench around the wards to keep their floors dry in case of possible rain. When rain is probable the tent-ropes should be relaxed, lest their contraction dislodge the pegs and endanger the stability of the canvas.

In the establishment of camp each man, by drill and experience, knows his particular duty, and, by doing it heartily, accomplishes the whole with ease and rapidity. Less than an hour will suffice to transform a deserted field into an hospital settlement as orderly and perfect in its appointments as if it had existed there for years. With dinner the labors of the day are at an end, save for the camp guard over the wagons and horses, the hospital guard, if the season requires one to attend to the fires, and the special work of the doctor and nurse in particular cases.

If, however, the sick do not number more than the ambulances can accommodate with bed-room—when the camp is reached late at night and an early start is anticipated—if the evening is wet and discomfort would attend the transfer of the sick to the tents, or even if the roads are miry and it is undesirable to have the hospital canvas made so much heavier by the rain, the patients may be permitted to pass the night in the ambulances ; so that these vehicles and their accompanying medicine wagons may constitute the division field-hospital in camp as well as on the march. Under such circumstances, if the number is larger than can be accommodated in the ambulances, tents may be pitched for the slighter cases, while those of a more serious character remain undisturbed under the ambulance covers.

When *reveille* is sounded in the command, the teamsters groom, feed, and water their horses, the stretcher-bearers pack up their blankets and shelters, and fill the ambulance kegs with fresh water ; breakfast is eaten ; the sick are examined, and medicines prescribed and provided for their use during the day, after which they are transferred to the ambulances, while their recent quarters and bedding are packed up and stored away in the wagons, which have by this time reported for their loads. When the troops fall in, the ambulances are in line, ready to move off in rear of their command ; but the transport wagons remain in camp until all the troops have passed, and then join the column of the supply train. Thus another day's march is commenced.

With veteran soldiers long marches may be made without a man presenting himself at the ambulances, but with raw troops the sick and worn-out accumulate from day to day, until it becomes imperatively necessary to make other provision for them. The medical director arranges for the relief of the hospital by sending the cases to the base of supplies, in such transportation as he may be able to procure from the chief quartermaster. The duty of the hospital surgeons in this event is to select the cases for the rearward journey, retaining those whose disability is of a temporary character. The surgeon in charge provides them with rations for their journey, and such medicines and medical stores as may be necessary. The

Army Hospitals.

medical officers and attendants to accompany them are detailed from the regiments by proper orders.

In the absence of transportation, the sick may have to be left in quarters extemporized for their occupancy in some village or settlement, or, if need be, a portion of the field-hospital outfit may be left temporarily with them.

But the march leads to an encounter with the enemy. A severe engagement is not a matter of precipitation. Large masses of men move slowly. The position of the enemy is known with more or less accuracy for days before the battle is fought. If the army is on the defensive, the lines are established with care and deliberation; if on the offensive, the position of the enemy has to be felt before the dispositions can be made for the attack. This gives more or less time, which must be utilized by the surgeon in charge in preparing for the coming event.

First, as to the selection of a position. The medical director, who has ridden along the formed or forming line of battle, indicates to the surgeon in charge, personally or by messenger, some notable point centrically situated in rear of the line, as a suitable location. The ambulance officer, on his return from a survey of the lines and the roads leading therefrom, may be the bearer of this order. The particular locality in this neighborhood is selected by the surgeon in charge, with due consideration to proximity to water and fuel, dryness of site, facility of communication with main roads leading to front and rear, availability of neighboring buildings as hospital accessories, and shelter from artillery fire, although this last has usually been considered in the instructions of the medical director.

It is better that the hospital should not be too near the front. Nothing is so depressing to the wounded, already more or less prostrated by their injuries, than exposure to fire while under the hospital flag, as it is suggestive of a disaster to the line of battle, with possible capture and deprivation of the kindly attention of friends, and of the home-nursing on which they had calculated for the period of their convalescence. Even in the best disciplined establishments the effect is sometimes demoralizing. The hospital camp cannot be removed further to the rear, under these circumstances, without detriment to the interest of the wounded already brought in; while those on the field have to be left for so much longer before obtaining the shelter and care which the hospital establishment was intended to provide. A distance of two miles from the front to the site selected will prevent the unnecessary occurrence of accidents of this nature; while if the roads are good, there will be little delay in the transport of the wounded.

If the line of battle is driven back, the exposure of the hospital is an unavoidable result, unless anticipated by prompt action on the part of those in charge. A rearward move under the circumstances is not effected at the expense of the wounded on the field, as they are without the lines, and dependent for succor on the hospital arrangements of the other side.

The neighborhood of a farm-house, country seat, or other occupied, or recently occupied, dwelling presents many advantages. It is a landmark, and will not so readily be missed by wounded soldiers seeking the hospital on foot. It will be in direct communication with the roads, and water and fuel will be found near it; while if it and its vicinity become exposed to artillery fire, it offers a point of advantage for the display of the hospital flag.

Our surgeons, during the Civil War, preferred, for these reasons, the vicinity of a notable dwelling as a site for their field hospitals, although, at least during the later periods, they seldom made use of its rooms as hospital wards, except as adjuncts or diverticula, when an unusual influx of wounded necessitated some provision for shelter outside of their hospital canvas. Experience taught them that only by providing their own shelter, and thus rendering themselves independent of fortuitous circumstances, could they at all times and in all places be prepared to give adequate shelter to their wounded. When depending, as often happened during the early part of the war, upon the accidents of the field, their patients, in unfavorable conditions, had either to remain without cover or be overcrowded in the available rooms.

When the site is selected, or even prior to the decision as to the specific locality, the ambulances proceed to the front and report at the points considered suitable for ambulance depôts, while the baggage wagons are brought into position ready to unload their material when required. At the ambulance depôts the stretcher-bearers await the onset under the orders of the ambulance officer and his sergeants. In rear, the pioneers, nurses, cooks, and teamsters undertake the routine work of unloading, pitching, and furnishing the tents, building fires, and preparing beef-soup, tea, and coffee, under the orders of the surgeon in charge; while certain of these men, with the hospital stewards, raise the operating flies, or shelters, and furnish them with their tables, instruments, and appliances, under the direction of the operating surgeons.

There is in every army a small percentage of men who, although borne on the rolls of the fighting force, are practically non-combatants. Musicians and boys belonging to the drum-corps, neither of whom carry muskets, are of no value as a class on the line of battle, and, under existing orders in most services, they are of no value anywhere else during the momentous hours in which victory or defeat results from the military operations. On orders issued by the adjutant-general, these men may be utilized as temporary aids to the medical department at the ambulance depôts and hospital. A certain number, detailed by name, may, by a standing order, be made to report to the surgeon in charge as soon as their commands deploy into line. This will bring them to the hospital in time to aid the pioneers in pitching the tents and preparing the hospital camp for the reception of the wounded. Thereafter they may be employed according to their individual capacities, the main body, however, being assigned to duty as the police party of the camp. Many medical officers have reported against the use of drum-corps details for hospital purposes on the ground that they are troublesome and unmanageable; but as others have credited them with valuable services, variations in executive ability are suggested in explanation, rather than dissimilarity in the character of details from the same class of men.

Injuries of the hand or flesh wounds, attended with little hæmorrhage or shock, are usually the first cases to reach the hospital. They have received primary dressings at the ambulance depôts, and have made the journey thence on foot, anxious to get away from the scene of danger. Their wounds are examined and recorded, and each is assigned to the ward of a certain ward-master, who will thereafter be responsible for his comfort. Blankets, overcoats, and shelter-tents are frequently thrown away in the hurried marches or rapid movements which sometimes prelude a battle; but if the soldier is in possession of these articles when wounded, they generally reach the hospital with him. The shelter-tents belonging to these first-comers are pitched at regular intervals in rear of the hospital tents, forming the ward to which they have been assigned. The pioneers attend to this work, trenching the ground, weather-guarding the shelters, and providing some material, such as hay, straw, freshly cut grass, leafy twigs, wood shavings, etc., as a mattress. If no material available for bedding can be found in the immediate vicinity, one of the now empty transport wagons may be despatched to some point where a supply may be obtained, and if no such point is known a detachment of the drum-corps may be sent out under responsible leadership as foragers. During inclement weather these slighter cases may be housed in the hospital tents until their special camp is prepared. When thus systematically camped, the wants of the wounded are not likely to be overlooked, as each ward-master has his duties aggregated and defined.

But in the meantime the ambulances arrive from the field, and the whole staff of the hospital becomes at once actively engaged. Should the news from the front indicate that the tents will be insufficient for the accommodation of the wounded, the flies are removed and pitched as extensions of the wards, and the bed sacks filled with such

suitable material as may have been collected in the neighborhood. If the ground is dry and the weather favorable these extemporized mattresses may be used without bedsteads; but it is well to have it understood as a standing rule in the establishment, that no severely wounded man should be permitted to lie on the ground. Raised bedsteads, however rude their construction, give to the wounded a sense of comfort which they cannot realize while lying as in bivouac. They contribute, moreover, to the facility with which dressings are applied, and to the cleanliness and general appearance of the wards. Hence, as soon as the flies have been extended a force should be set to work to build *bunks* for the expected patients. If the extension of the wards by means of the flies is insufficient for the shelter of the incoming wounded, recourse may be had to the accommodation offered by the neighboring dwelling or its out-houses; but with the hospital establishment organized as stated, this will be needful only on exceptional occasions.

Should the enemy retire to another position under pressure of the attack, it is not necessary for the hospital to follow the consequent advance of the troops. The ambulances will have to make a longer journey to reach it; but it would be better for them and for the recently wounded to undertake this than for the whole establishment to make a forward move. Should the advance in pursuit carry the lines so far from the hospital as to seriously impair its usefulness, a forward move may be ordered, provided its wounded and sick can be carried in the ambulances and other wagons at the disposal of the surgeon in charge; but if the wounded cannot be thus transported, the orders will probably direct the hospital to be ready to move at a given hour, by which time all operations are expected to be performed and the wounded to be in condition to undertake a rearward journey in wagons specially provided for their transportation.

The surgeon in charge superintends the loading of these wagons, and provides for the comfort of the wounded by supplying the medical officer who is detailed from his regimental duties to accompany them with such articles of food and medicine as may be needful. He may have to part with some of his mattresses, bedsacks, and blankets in fitting out this train; but, if necessity calls for it, requisitions can at the same time be sent to the base of supplies to have them replaced on the first opportunity.

Should the orders transmitted by the medical director require a forward movement of the hospital establishment, while no provision is made for the removal in the opposite direction of the wounded already accumulated, rations must be drawn from the general supply train and left with them, together with the necessary supply of medicines, stimulants, dressings, etc., required for the probable period of their stay and subsequent journey. Under these circumstances much of the hospital material may have to be left behind for the time being, under charge of an ambulance officer, with the wagons needful to insure its return to the hospital on the departure of the wounded to the base of supplies. The hospital may thus be temporarily disabled, but the greater its disability, the less is the likelihood of its being again called into serious action without time being afforded for recuperation; for the disability from this cause is proportioned to the loss inflicted on the command to which it is attached. If the command has suffered considerably, it will probably be placed in reserve for a few days, by which time the hospital material will have returned to the front.

But should a fiercely contested battle be fought, giving twelve or fifteen hundred wounded to each of the division hospitals, the lines become so broken, and the troops so exhausted, that time must elapse before either party is in condition for a renewal of the contest; ammunition, food, forage, and, perhaps, clothing wagons, have to be ordered up for use. The resumption of hostilities is a gradual process, preceded by feints and manœuvres to develop the antagonist's strength, gain position, or await reinforcements. The existence of the hospital on the ground selected at the beginning of the battle may thus be measured by days instead of hours, and ample time may be afforded the surgical staff for the completion of its labors; but the uncertainty which is inherent in all battle-field conditions, renders it important that every effort should be made to have the wounded in condition for removal at the earliest possible moment. As soon, therefore, as the battle has ceased, certain medical officers, who have hitherto been on duty at the front, are directed to report to the surgeon in charge for assignment to temporary duty at the hospital, where tables are extemporized for their use, and the progress of the operative work is correspondingly hastened; or, the extra surgical help may be derived from the base or general hospitals, especially if telegraphic and railroad connections have been kept up. The aid required under these circumstances is skilled surgical assistance, to enable the hospital to complete its field operations. It is provided, as has been seen, with the needful shelters, supplies, and appliances for a large aggregation of wounded, and with the surgical aid requisite for the operative work, provided time is afforded in which to accomplish it; but as this important element is not always available, surgical aid from the front or rear is always of value.

Should the troops in the line of battle be driven back, and the hospital establishment become exposed, the surgeon in charge must take prompt measures to prevent its capture by the enemy. All the wounded who have been brought in should be removed, with the hospital material, to a suitable site in the rear of the position newly assumed by the troops. The wounded left upon the field must be cared for by the medical department of the opposing force, but such as have reached the shelters prepared by friends should not be given up without the strongest efforts on the part of those in charge to save them. If there is, unfortunately, no time to effect the removal of all, such as must be permitted to fall into the hands of the enemy should be left with as comfortable surroundings as if they were still within the lines. Hospital canvas, bedsteads and bedding, medical and surgical supplies, and food, must be left with them, and such medical attendance as their number may require should be detailed to remain with and surrender them. Shelter and furniture thus lost to the hospital should be renewed by immediate requisition on the supply depôts.

If the disaster is so serious that none of the wounded can be removed, the surgeon in charge should endeavor to preserve the hospital organization by withdrawing the ambulances, wagons, surplus stores, and *personnel* not specially detailed to remain with the wounded. When the hospital establishment is thus disabled, an immediate renewal of hostilities necessitates the occupation of the available buildings in the neighborhood of the new site; but this utilization of pre-existing shelter would have been necessary if, without the repulse, the wounded had by their number called for increased accommodation. The graver cases are received and bedded in the dwellings or their out-houses, and the slighter cases camp in their canvas shelters as before. Food, medicines, surgical appliances, etc., are furnished from the wagons which have been saved, and the operating staff is reorganized if it has suffered loss.

If the disaster involves the capture of the transportation and supplies, while more or less of the officers and men have escaped, to undertake the duty of aiding the wounded who may fall in the skirmishes of a subsequent retreat, a work is presented to these members of the hospital establishment which will be accomplished with an efficiency depending, *cæteris paribus*, on their previous discipline. Notwithstanding breaks in their ranks, their training holds them together as a machine constituted for a specific purpose. Wagons for the transport of the wounded, and of supplies obtained from the hospitals or purveying depôts, may often be obtained from the army trains. The light headquarters' wagons were, on several occasions during our Civil War, transferred to the hospitals, to form the nucleus of an extemporized ambulance system, and the work of collecting, treating, and providing for the wounded has thus gone on with more or less of precision and efficiency.

It sometimes happens, however, that the conditions of

a campaign deprive the surgeon in charge of his transport wagons and their contents during some part or the whole of an engagement, although no previous disaster has taken place. Thus, the army having to execute a rapid movement, would be impeded by the pressure of the heavier wagons. An ambulance officer is left behind with them, with instructions to bring them forward on the earliest possible opportunity. If the troops become engaged before their arrival, the ambulance boxes and medicine wagons afford the necessary supplies, and keep the *personnel* at work on behalf of the wounded until the remainder of the train reaches the ground. Or, a river has to be crossed, over which it is considered injudicious to bring the heavier portion of the train until the troops have established their position on the further side. In this case, also, the supplies in the ambulance boxes will be of value to the wounded until the transport wagons reach the scene of action.

When the army goes into winter quarters, and occasionally during sieges, the character of the division field-hospital may undergo a seeming change. As there is no immediate prospect of a move, the sick and wounded need not be sent away unless they have accumulated beyond the capacity of the hospital to accommodate them. Commanding officers approve of retaining the sick and wounded in the field-hospital while in somewhat permanent camps, as the return of their men on recovery is insured; they become interested, therefore, in these field-hospitals, and further the efforts of the medical officers in improving their condition. Under such circumstances lumber can usually be obtained, and the tents may be pitched upon frames, and be floored and weather-boarded as high as the eaves; shelves, tables, and benches may be put in as fixtures and furniture, and the ward be warmed by an open brick fireplace built at one end. Stoves are unmanageable under canvas, and extemporized underground furnaces and fires are dangerous. If the ground is damp, plank pathways are laid for access to all parts of the hospital camp and its grounds, which should be enclosed by a fence and thoroughly policed. As thus finished, the hospital presents an air of permanence and stability; but if kept in proper drill, a few hours, notice only is required to have it packed up and waiting its place in the column of march.

TABLE OF 245,790 GUNSHOT WOUNDS.

(Compiled from the "Surgical History of the War of the Rebellion.")

Region and character of wounds.	Total wounded.	In every 100 wounded. Cases.	Primary operations.	Immovable dressing.
Wounds of scalp	7,739	3.15		
" skull	4,350	1.77		
Flesh wounds of face	4,914	2.00		
Fractures of face	4,502	1.83		
Wounds of neck	4,895	1.99		
" spine	642	.26		
Flesh wounds of chest	11,549	4.70		
Penetrating chest	8,715	3.55	1.00	
Flesh wounds of abdomen	4,748	1.93		
Penetrating abdomen	3,690	1.50		
Wounds of pelvis	3,159	1.28		
" back	12,681	5.16		
Flesh wounds, upper extremity	54,801	22.30		
" " lower extremity	59,139	24.06		
Fractures of—				
Clavicle and scapula	2,280	.92		
Shoulder	1,579	.65	.86	1.21
Humerus	8,245	3.35		
Elbow	2,816	1.15	1.70	2.80
Forearm	5,194	2.11		
Wrist	1,509	.62	.72	2.00
Hand	11,369	4.62	2.07	
Hip-joint	386	.16		
Femur	6,738	2.74	1.72	2.57
Knee-joint	3,398	1.38		
Leg	9,171	3.73		
Ankle-joint	1,722	.70	1.50	2.94
Foot	5,859	2.38	.30	
	245,790	100.00	9.37	11.52

Charles Smart.

ARNEDILLO, in New Castile, near Pampeluna, lies at an altitude of 325 metres (1,066 feet) above the sea. It has a thermal spring of a temperature of 51.8° C. (125.2° F.), containing 3.52 parts per 1,000 of solids, chiefly sodium chloride, aluminium sulphate, and iron. There is present a little free CO_2. Taken in copious draughts the water acts as an agreeable aperient, in small quantities it is astringent. Arnedillo has been resorted to almost exclusively for the treatment of syphilis, but of late years sufferers from malarial cachexia, rheumatism, and dyspepsia have increased the number of its patrons. The water must be taken in great abundance to produce medicinal effect. *H. F.*

ARNICA (*Arnicæ Flores*, U. S. Ph.; *Flores Arnicæ*, Ph. G.; *Arnicæ Radix*, U. S. Ph., Br. P.; *Arnica*, Codex Med.; Root, leaf, and flower-head).

Arnica Montana Linn. (*Doronicum montanum* Lamk.), Order, *Compositæ*, *Senecionideæ*, belongs to a small genus of rather low, simple-stemmed herbs, with large, radiate, yellow, usually solitary flower-heads, and simple, opposite, generally entire, leaves. The officinal arnica plant is from thirty to sixty centimetres (one to two feet) in height, rising from a horizontal or ascending rhizome, with a star of petioled leaves near the ground, and one or two pairs of smaller leaves on the stem. The stem, leaves, and inflorescence are mostly glandular-hairy; the flowers are rich golden, or orange-yellow. As all parts of the plant are used in medicine, the further description is given below from a pharmacological, instead of a botanical point of view. It is especially a native of Europe, in the wastes and mountains of which it is very abundant, but it grows as well in Siberia and in northern North America, and it is not always easy to cultivate. It is imported from Europe.

Arnica has passed through several fluctuations of favor and neglect since its first introduction into medical use. It appears to have been an article of popular medicine in Central Europe at least as far back as the sixteenth century, and was urged upon the profession by numerous physicians in the seventeenth, when it was a good deal used, as well as in the eighteenth. Early in the present century it had fallen much into disuse, but was revived again about the middle of the century, chiefly as a popular vulnerary. Very lately it has been going out of fashion again, its place in popular taste being taken by Hamamelis and other things. Internally it has been a good deal tried, but is now very little employed.

FIG. 262.—Arnica; flowering-head. (Baillon.)

Arnica Flowers, as the flower-heads are usually called, are from three to six centimetres across (one and a fourth to two and a half inches) with a two-rowed involucre of lanceolate scales, the outer ones glandular. The ray-flowers number from sixteen to twenty, the disk-flowers being much more numerous. The receptacle is flat and pitted. Achenia five-angled, glandular, hairy, surrounded by a stiff brittle pappus; corolla tubes also hairy. Ray-flowers pistillate, disk-flowers perfect. Odor not very strong, peculiar, recalling that of Grindelia, and some other *Compositæ*; taste bitter, acrid. Dust sternutatory. Usually the drug consists of the entire *capitula*, but sometimes the flowers are separated and constitute the whole.

Arnica Leaves are not much used. They are lanceolate, with tapering bases, entire, and from one- to three or five-nerved, according to size and position; they are

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MEDICAL

ARNICA MONTANA.

rather stiff, rough above, and smooth beneath. Their properties are those of the flowers, but weaker.

Arnica Root.—This consists of the sparsely scaly, dark-brown rhizome and its adherent roots. It is brittle, often bent, from two to six centimetres long (one to two and a half inches), and from four to five millimetres (one-sixth to one-fourth inch) in diameter. It is rough, irregularly ringed and knotted, and has numerous brittle, simple rootlets attached to one side, all the way along. They are about one millimetre in diameter, and two or three centimetres in length. The external color of the rhizome is dark-brown, of the roots lighter. Internally it is a grayish-white, with a circle of darker oil-tubes, etc., in the cortical portion. Taste sharp, bitter, persistent. Odor slight.

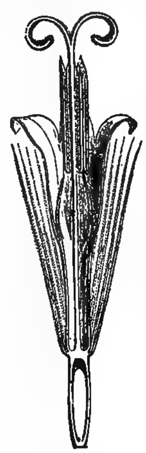

Fig. 263.—Single Flower of same. (Enlarged.)

The chief constituents are the *oil*, of which it contains about one per cent., and a crystalline bitter principle, *arnicin*. The oil of arnica has a peculiar composition.

Internally administered, Arnica has a decided action upon the animal organism, especially upon the gastric and intestinal tracts, causing vomiting, pain in stomach and bowels, colics, diarrhœa, etc. It may cause death, as in a case recorded by Wilms (quoted by Hager), with symptoms of gastro-enteritis, where the amount taken was from fifty to eighty cubic centimetres (fourteen to twenty drachms) of a ten per cent. tincture. It may also produce dizziness, faintness, headache, sweating, increase of urine, etc. It is said to cause bloody milk in cows. The above effects do not recommend arnica much for internal use, still it has been given for nervous, spinal, and urinary troubles, fevers, etc. Such internal use of the drug is now rare. Externally and locally Arnica is a favorite ingredient of popular vulneraries; it is stimulant, sometimes (if concentrated), irritant to some skins and it may even give rise to the formation of pustules. Dose, from four to twelve decigrams (0.4 to 1.2 Gm., gr. vj. to xviij.).

The preparations are Extract of Arnica Root (*Extractum Arnicæ Radicis*, U. S. Ph.), a tincture evaporated to a moist mass and preserved from drying by a little glycerine; used to make Arnica Plaster (*Emplastrum Arnicæ*, U. S. Ph., one-third with two-thirds Resin Plaster); Fluid Extract of Arnica Root (*Extractum Arnicæ Radicis Fluidum*, U. S. Ph., strength, $\frac{1}{1}$); Tincture of Arnica Root (*Tinctura Arnicæ Radicis*, strength $\frac{1}{10}$), and finally Tincture of Arnica Flowers (*Tinctura Arnicæ Florum*, U. S. Ph., strength $\frac{1}{5}$).

ALLIED PLANTS.—For *Compositæ* see CHAMOMILE.

ALLIED DRUGS.—Internally Veratrine, Turpentine, Antimony, and some of the other *Compositæ*. Externally, numerous stimulating drugs and liniments—Turpentine, Oil of Cajeput, Thapsia, etc. *W. P. Bolles.*

ARNSTADT, a city situated in the Thuringian forest of Saxony, at an altitude of 309.7 metres (1,006 feet), contains scattered about its environs numerous chlorinated springs, the therapeutic effect of which is augmented by the equable and mild climate of this region. The mountain air is bracing and singularly pure. The thermometric variation is seldom more than 5° C., and often less during the summer days, though the nights are cooler. The temperature of the water is only 11° C. (51.8° F.): it contains 24 per cent. of solid matters, but the baths are taken in a dilution of one part in three.

The composition of the water is as follows:

Sodium chloride	224.000
Calcium chloride	6.450
Magnesium chloride	5.110
Magnesium iodide	0.001
Magnesium bromide	0.054
Calcium sulphate	1.700

The waters are evaporated so that the residue contains 421.4 parts total solids per 1,000, with a disproportionate increase of bromides and iodides; this is then diluted with simple carbonated water, and used as a beverage, or is bottled for export. At Plaue, in the neighborhood of Arnstadt, is the "Riedquelle," a chlorinated spring, the water of which is used undiluted, or in admixture with milk and whey. It is indicated for infantile struma, and inflammation of the mucous membranes in general. The Riedquelle water contains 4.959 parts solids per 1,000, in the following proportions:

Sodium chloride	3.706
Calcium chloride	0.004
Magnesium chloride	0.068
Sodium sulphate	0.208
Magnesium sulphate	0.120
Calcium sulphate	0.416
Sodium carbonate	0.267
Free carbonic acid, 71.564 Cc.	

The temperature of this spring is 15° C. (59° F.). There are at Arnstadt two large bathing establishments with complete apparatus for vaporization of the water, inhaling apparatus, pine baths, promenades, and other improved and modern aids to the water cure.

Henry Fleischner.

ARROW-HEAD HOT SPRINGS. *Location and Post-Office*, San Bernardino, San Bernardino County, Cal.

ACCESS.—By Southern Pacific Railroad to Colton, thence by stage to Springs, ten miles distant.

ANALYSIS.—No reliable analysis had been received to date, but the water is said to be strongly impregnated with iron, combined with magnesia, sulphur, and iodine.

THERAPEUTIC PROPERTIES.—Without a knowledge of the chemical composition of these waters it is impossible to judge of their medicinal value. However, having a temperature from 180° to 210° F., they should be of benefit in rheumatism, gout, and skin diseases. Provision is made for the treatment of these cases by steam- and mud-baths. It is also claimed that they are efficacious in kidney, liver, and stomach affections.

The springs, twelve or more in number, are situated in the foot-hills north of San Bernardino, at an altitude of 2,000 feet. They issue from a species of granite, mixed with silica.

The climate is delightfully pure and balmy. The temperature is never oppressively warm, and rarely ever reaches the freezing-point. On account of the altitude fogs seldom prevail. For sufferers from lung and bronchial troubles this region is a favorite resort.

The present proprietors of the Springs, who have lately come into possession, have erected a large, first-class hotel, and heated it by the water from the Springs. The bathing facilities have been renovated and enlarged. They include a hot-water swimming pool, seventy by one hundred feet, and from five to twelve feet deep.

The scenery from the Springs is grand and beautiful. To the north are snow-capped mountains, while on the south the beautiful valleys of San Bernardino and Riverside, with their orange-groves, vineyards, and grain-fields, are spread out against a background of the Temescal Mountains, thirty miles away. There are churches and schools at San Bernardino, six miles from the Springs.

G. B. F.

ARROWROOT (*Arrowroot de la Jamaïque*, Codex Med.). The starch obtained from *Maranta arundinacea* Linn. Order, *Scitamineæ*; tribe, *Marantaceæ*.

The Marantas form a small group of this most interesting tropical, or subtropical, order, of which Ginger and the Cannas are other conspicuous examples. They differ from the former principally by having but one anther-cell and a one-seeded fruit, and from the latter also by their one-seeded fruit. They are perennial herbs, with tuberous or thickened starch-laden, scaly rhizomes, and leafy, often branched, stems. The flowers partake of the peculiar irregularity of the order, although not so showy as many, in being principally composed of the petal-like staminodia, or barren stamens. The cultivated Cannas, so common in gardens, will serve as an illustration of the order.

The arrowroot plant is a native of tropical America, including the West Indies. It is also extensively cultivated, and has been introduced into nearly all tropical countries. A large amount of arrowroot is now produced in Southern Asia. The Indian plant differs somewhat from the American, but is considered as only a variety of it.

The early medicinal application of arrowroot among the aborigines appears to have been as a remedy for the wounds of their arrows, to which it owes its name. It was both given internally, and applied as a poultice to the injured part. It was also used as a food. Accounts of its cultivation in the West Indies date back about a hundred and fifty years, since which time it has been an article of general commerce.

Arrowroot is prepared in essentially the same way as other starches, namely, by washing it out of the cellular tissue. The rhizomes are carefully cleaned and ground, then the pulp is washed over sieves, through which the starch passes with the water into reservoirs, where it gradually subsides to the bottom. It is washed over and over with clean water, until perfectly white and pure, and is then dried. The yield is about ten per cent. of the fresh rhizome. It is manufactured in a number of tropical countries, several of the West India islands, Brazil, India, etc., but that of the West Indies, generally called Bermuda arrowroot, is regarded as the best. It is a beautifully white, lumpy powder, without odor or taste; rubbed between the fingers it gives a slight crackling sound, or rather, feeling, for the sensation is conveyed more through the fingers than the ears. Its other properties are simply those of starch in general, to which the reader is referred.

When the antiphlogistic treatment of diseases was more in vogue than at present, arrowroot took quite an important place in the dietary of the sick. It was also extensively used as an ingredient of foods for infants. For neither of these purposes is it to be much recommended. As a food it has scarcely any advantages over the cheaper indigenous starches now so admirably prepared.

Allied Plants.—Species of *Canna* and *Curcuma* yield similar starches. For notice of the order, see Ginger.

Allied Drugs.—See Starch. *W. P. Bolles.*

ARSENIC. 1. General Medicinal Properties of the Compounds of Arsenic.—The predominant feature of the action of arsenical preparations is intense irritation. Locally applied in fairly concentrated form to a denuded surface the irritation is so severe as to excite the extreme of reaction, namely gangrenous inflammation; the part sloughs, strangulated by congestion and inflammation. Arsenic is thus indirectly, and because indirectly, slowly, painfully, and dangerously, caustic. Applied so as to cauterize, there is also a risk of absorption of enough arsenic to produce constitutional poisoning, a risk greater when the application is weak than when it is strong, since in the latter case congestion is developed early, whereby absorption is impeded. When arsenic is taken internally, gastro-intestinal irritation is easily produced, and in acute arsenical poisoning constitutes the most prominent feature of the derangement. Apart from tendency to irritate, arsenic is fairly antiseptic, and upon the higher organisms, such as man, has an action upon the nervous system. In arsenical poisoning nervous symptoms are prominent, and, therapeutically, much of the avail of arsenicals hinges upon the allaying of nervous derangements.

For the purposes for which arsenic is used in medicine, the remedy has to be administered continuously for days, weeks, or months. In so giving it the rule is to adjust the dosage so that no obvious disturbance is set up. Such disturbance, the beginnings of poisoning that is, shows itself first in an irritation of the conjunctiva, the eye becoming suffused and smarting, and the lower lid puffy from œdema; and secondly, in an irritation of the stomach, shown by failure of appetite and soreness and sensation of weight at the epigastrium. In some persons the gastric symptoms precede the conjunctival. The two sets of symptoms should be watched for in arsenical medication, and the dosing diminished or temporarily discontinued until their abatement, which speedily follows the withdrawal of the poison.

The therapeutically valuable properties of arsenic are as follows:

(*a*) *Improvement of Nutrition.*—Even in the healthy, carefully graduated dosage with arsenic tends to improve general nutrition, the individual fattening, the skin being specially rosy and smooth, or, in animals, the fur sleek and glossy, and the bones thick and dense.[1] In the so-called arsenic-eaters of Styria, the women are said to indulge for the beautifying of their complexion, and the men for the improvement of their wind and the increased physical endurance which they claim to derive from the use of arsenic. This habit of regular consumption of arsenic among certain of the working-class in Styria seems now established as a fact by competent and reliable testimony.[2] Arsenious acid is the preparation commonly used, and the daily allowance has been known to reach five and even ten grains. But attempts in other countries to acquire the tolerance of the poison which the Styrian peasantry show, commonly end in disaster. The property of arsenic to modify nutrition is availed of principally in the following diseases:—*Progressive Pernicious Anæmia:* In this affection, where iron is so notoriously futile, arsenic has in many cases proved of great benefit, patients even recovering fully under its use. It is probably at the present writing the most important medicinal agent for the treatment of the disease. *Scaly Skin Diseases:* In skin diseases arsenic is more or less used, but experience agrees that it is vastly more likely to be of benefit in affections of the epidermis than in those involving the corium. *Psoriasis* is a typical disease of the former kind, and in its treatment arsenic is a standard remedy. At the beginning of an arsenical course the symptoms often suffer an exacerbation, but this commonly subsides in a few days. The medicine should not be prescribed during the inflammatory stage of a skin disease, but when used should be persisted in for weeks, or even months, after apparent cure. Under all circumstances the remedial action is slow.

(*b*) *Control of Neuroses.*—The property of arsenic to affect nerve-functions, seen in the nervous phenomena that attend arsenical poisoning, shows itself therapeutically in a tendency to abate pain, spasm, and undue reflex irritability. The property is utilized most especially in the following conditions:—*Gastric Irritability:* In idiopathic dyspeptic irritability of the stomach, or in the irritability attending the chronic gastritis of drunkards, or ulcer or cancer of the stomach, arsenic is often of considerable benefit, and is especially efficacious where the nervous disturbance is disproportionately great to the extent of the lesion. *Neuroses of the Respiratory Organs:* Certain asthmatics find a certain amount of temporary relief from arsenic, a relief more likely to be obtained in the pure neurotic form of the disease than where the symptoms are secondary to bronchitis, emphysema, or disease of the heart. Yet also the nerve-irritation in coryza may be relieved, and, according to Ringer, paroxysmal sneezing is often promptly broken by the remedy, except when caused by true hay fever, the result of the inhalation of pollen. *Other Neuroses:* In *chorea* arsenic is probably the most generally serviceable of medicines, an opinion so universally held that discussion is unnecessary. Simple uncomplicated cases recover under the use of the remedy more frequently than not. *Neuralgia* also sometimes yields to arsenic, more particularly when the attacks show a regular periodicity of onset; in other words, when the affection is very likely of malarial origin. Other neuroses also, such as angina pectoris, and even epilepsy, have occasionally been treated by arsenic, and isolated cases have been reported where benefit has been claimed from the medication.

(*c*) *Control of Malarial Diseases.*—Arsenic has a notorious power over malarial affections, being commonly resorted to as next choice after the cinchona alkaloids. In a broad way it is inferior in potency to those alkaloids, but yet in old cases, and particularly in intermittents of

tertian and quartan rather than quotidian type, it may succeed even after quinine has failed. As compared with quinine, furthermore, arsenical preparations are tasteless and cheap, and for those reasons alone may be selected for prescription in malarial disease with the poor or with children.

Besides the foregoing, arsenic has been used in a great variety of diseases on the general principle of being an "alterative," with alleged success in many cases.

2. THE MEDICINALLY USED PREPARATIONS OF ARSENIC.—The arsenical compounds used in medicine are the *trioxide* (arsenious acid), *triiodide*, and the two salts, *potassic arsenite* and *sodic arsenate*.

Arsenic Trioxide, As_2O_3, *or* As_4O_6. This well-known compound is officinal in the U. S. Pharmacopœia as *Acidum Arseniosum*, Arsenious Acid, an appellation which chemically belongs only to the aqueous solution of the oxide. This is the preparation also known as *white arsenic*, or, in common parlance, simply *arsenic*. Arsenious acid, so-called, is "a heavy, white solid, occurring either as an opaque powder, or in transparent or semitransparent masses which usually have a striated appearance; permanent in the air, odorless and tasteless, and having a faintly acid reaction. Soluble in 30 to 80 parts of water at 15° C. (59° F.), the solubility varying with its physical condition. It is slowly but completely soluble in 15 parts of boiling water. In alcohol it is but sparingly soluble. It is freely dissolved by hydrochloric acid, the alkalies and their carbonates, and is moderately soluble in glycerin. When heated to about 218° C. (424.4° F.) it is completely volatilized, without melting, and when thrown on ignited charcoal, it emits an alliaceous odor" (U. S. Ph.). Arsenious acid is obtained by sublimation, by roasting ores containing arsenic, and is subsequently purified by resublimation. When first obtained it is in transparent glass-like masses, but these, in after-exposure, acquire the porcelain-like appearance in which arsenious acid is commonly met with in the shops. This change, beginning on the surface, gradually extends in time throughout the whole thickness of the mass; not so quickly, though, but that commercial samples may often be found where the masses, on fracture, show a vitreous interior. For medical use the mineral is pulverized, appearing then as a very fine, white, smooth powder. In this condition it is easily adulterated, but the fraud can be readily detected by submitting the sample to sublimation, when the arsenious acid will all disappear by volatilization, and the impurities be declared by a non-volatile residue.

Arsenious acid possesses all the physiological properties of arsenicals as above set forth. It does not act upon the sound skin, but upon a mucous membrane or denuded surface produces violent irritation. Taken internally it is readily enough absorbed to produce the constitutional effects of arsenic, therapeutic or toxic, and may be so used, as a medicine, in doses of 0.003 Gm. (one-twentieth grain) three times a day, generally given in pill. But it is not an eligible preparation for internal use, because of the local irritation it is apt to set up. Externally it has been employed to destroy the tissues of cancer or lupus, applied in ointment or paste. For such purpose the arsenious acid is mixed with from four to eight times its weight of inert matter, such as ointment or an indifferent powder brought to condition of paste by admixture of mucilage. Such arsenical ointment or paste is then applied to the tissue to be destroyed, the point being observed, if the part be covered by skin, to first remove the epithelium by blistering. The application is to continue for from twelve to twenty-four hours. Weak arsenical mixtures are more dangerous than strong, because of the greater likelihood of constitutional poisoning. Even strong applications, if at all extensive, are risky, and, at best, the destruction of tissue by arsenic is a slow, uncertain, and very painful process, not to be commended. Most of the numberless caustic pastes of quack "cancer-doctors" are preparations of arsenious acid. The following have been celebrated in their day:—*Arsenical Paste of Frère Côme:* Arsenious acid and animal charcoal, each one part; mercuric sulphide, four parts; to be used only over a small area at a time. *Sir Astley Cooper's Arsenious Ointment:* Arsenious acid and sulphur, each one part; spermaceti cerate, eight parts. *Plunket's Caustic:* Bruised plant of *ranunculus acris* and of *ranunculus flammula*, each twenty-four parts; arsenious acid, three parts; sulphur, five parts; the whole mixed to a paste, rolled into balls and these dried in the sun. For application the balls are to be again reduced to pasty consistence by rubbing with yolk of egg. In using this preparation, preliminary denudation of the skin is unnecessary, that operation being performed by the acrid matter of the crowfoot. The only preparation of arsenious acid officinal in the U. S. Pharmacopœia is what is entitled, now, *Liquor Acidi Arseniosi*, Solution of Arsenious Acid. This is a one per cent. solution of the arsenical in water acidulated with two per cent. of hydrochloric acid, and corresponds with what was called in the fifth revision of the Pharmacopœia "Solution of Chloride of Arsenic." The change of title is a proper one, since the hydrochloric acid merely determines the solution of the arsenious acid without entering into combination with it. The preparation is of the same strength as Fowler's solution (see below), and is given in doses of 0.30 Gm. (five minims) three times a day, largely diluted with water.

Arsenic Triiodide, AsI_3. This compound is officinal in the U. S. Pharmacopœia as *Arsenii Iodidum*, Iodide of Arsenic. It is in "glossy, orange-red, crystalline masses, or shining, orange-red, crystalline scales, gradually losing iodine when exposed to the air, having an iodine-like odor and taste, and a neutral reaction. Soluble in 3.5 parts of water and in 10 parts of alcohol at 15 C. (59° F.); also soluble in ether and in disulphide of carbon. It is gradually decomposed by boiling water and by boiling alcohol. By heat the salt is completely volatilized. The aqueous solution has a yellow color, and, on standing, gradually decomposes into arsenious and hydriodic acids" (U. S. Ph.). This iodide has been given internally as an arsenical in doses of 0.008 Gm. (one-eighth grain), and used externally on malignant growths in a one per cent. ointment; but its principal purpose among medicines is to furnish the pharmacist with the arsenical ingredient of the officinal preparation, *Liquor Arsenii et Hydrargyri Iodidi*, Solution of Iodide of Arsenic and Mercury, commonly known as *Donovan's Solution*. This is an aqucous solution of one per cent. each of the iodide of arsenic and the red iodide of mercury. It is a pale yellow fluid, slightly astringent in flavor, and precipitating with alkalies, silver solutions, and solutions of alkaloidal salts. It is used as a composite "alterative" internal medicine, its reputation being principally in the line of scaly skin disease, syphilitic, or idiopathic, and in rheumatic affections. Dose, from five to ten drops, well diluted with water, after meals.

Potassic Arsenite. An arsenite of potassium is officinal in the U. S. Pharmacopœia only in the solution, entitled *Liquor Potassii Arsenitis*, Solution of Arsenite of Potassium, better known by the common name of *Fowler's Solution*. This solution is made by boiling equal parts of arsenious acid and acid potassic carbonate in water, until chemical union is effected, then bringing the solution to the standard strength of one per cent. of arsenious acid, and adding a small charge of compound tincture of lavender. This latter addition is to give the preparation sufficient taste and color to prevent its being mistaken for simple water. Fowler's solution is clear, and tastes only of lavender. It is of alkaline reaction, and responds to the usual tests for arsenic. Physiologically it acts the same as would a solution of arsenious acid of like strength. It is in imitation of a famous remedy known as "tasteless ague-drop," and is the most convenient and commonly used arsenical for internal giving. The average dose is five drops, well diluted with water, to be taken, like all arsenicals, after eating, and repeated two or three times a day.

Sodic Arsenate, Na_2HAsO_4, $7H_2O$. The salt is officinal under title *Sodii Arsenias*, Arseniate of Sodium. It occurs in "colorless, transparent, prismatic crystals, slightly efflorescent in dry air, odorless, having a mild, feebly alkaline taste, and a faintly alkaline reaction. Soluble in four parts of water, and very slightly soluble in alcohol at 15° C. (59° F.); very soluble in boiling

water, and soluble in sixty parts of boiling alcohol. When gently heated, the salt loses 28.8 per cent. of its weight (water of crystallization), and, if further heated, to near 148° C. (298.4° F.), it loses the remainder of its water (11.5 per cent.)" (U. S. Ph.). Sodic arsenate has the usual properties of the arsenicals, but is a little milder than potassic arsenite.[3] It is generally prescribed in the officinal *Liquor Sodii Arseniatis*, Solution of Arseniate of Sodium, simply a one per cent. aqueous solution of the salt. This solution may be given in the same dose and manner as Fowler's solution.

Edward Curtis.

1 Th. Gies: Archiv für Experiment. Path., December, 1877, quoted in Phillips's Materia Medica.
2 Maclagan: Edinburgh Medical Journal, 1864, p. 203.
3 Ringer: Journal of Physiology, vol. i., p. 213.

ARSENIC, POISONING BY. Metallic arsenic, even if pure, may act as a violent poison, when taken internally, apparently by reason of its oxidation and solution in the contents of the stomach and intestines. Exposed to moist air it slowly absorbs oxygen, with the formation of arsenious oxide, and thus acquires poisonous properties. This mixture of arsenic and arsenious oxide, containing, it is said, from four to eleven per cent. of the latter compound, has been sold under the name of fly-powder, and has given rise to a number of cases of poisoning, most of which have been caused by the accidental ingestion of the poison by children. The symptoms and appearances produced by it are similar to those caused by arsenious oxide.

All the soluble compounds of arsenic, and some of the insoluble compounds, are poisonous. The principal compounds which have given rise to poisoning are: arsenious oxide, called also arsenious anhydride, arsenious acid, white arsenic, and arsenic; the arsenites of sodium, potassium, and copper; the arseniates of sodium and potassium; arseniuretted hydrogen (see Arseniuretted Hydrogen, Poisoning by); the yellow sulphide of arsenic, or orpiment, and the red sulphide, or realgar; arsenical colors, which include arsenite of copper, or Scheele's green; aceto-arsenite of copper, or Schweinfurt green; the sulphides of arsenic, and aniline and other coal-tar colors, which frequently contain arsenic in some form. The most important of these compounds are arsenious oxide and the preparations included under the term "arsenical colors." Of the solid compounds of arsenic, those which are most soluble are, as a rule, the most poisonous.

Acute Poisoning.—The principal source of acute poisoning is arsenious oxide, or white arsenic, which has given rise to a large number of cases of criminal, suicidal, and accidental poisoning. The opportunities for poisoning by this substance are much increased by the fact that it can be easily obtained for the extermination of household vermin, and for use as an antiseptic. It has, moreover, no appreciable taste, and is not therefore detected, as a rule, when taken into the mouth.

Symptoms.—The time at which the symptoms appear is subject to many variations, depending in great part on the dose, on the form in which it has been administered, whether as a solid or in solution, and on the condition of the stomach. The average period is from half an hour to an hour after the poison has been taken. Cases have been reported in which they have appeared immediately (Beck, Wharton and Stillé, Taylor); within eight and ten minutes (Christison); within fifteen minutes (Taylor). In others the symptoms have been delayed for several hours; five hours (Orfila), seven (Lachèse), eight (Tonnelier), nine (Ryan), ten (Belloc), and sixteen (Hartshorne).

When a large dose of arsenic has been taken, the first symptoms are usually nausea, and an intense burning pain in the throat, œsophagus, and stomach, followed by violent and incessant vomiting. The vomited matters consist, at first, of the contents of the stomach, but later, of mucus, bile, and sometimes blood. The pain soon extends over the whole abdomen, and is followed by violent purging and tenesmus. The stools are usually watery, sometimes resembling the discharges of cholera, and are frequently tinged with blood. There is usually intense thirst and a feeling of constriction in the throat; there are pains in the loins and cramps in the extremities. There is severe headache; the skin is cold, and covered with a clammy perspiration; at first pale, it later becomes cyanotic. The respiration is painful; there is great prostration; the urine is sometimes suppressed. Coma, convulsions, and partial or general paralysis not infrequently precede death, which, in this form of poisoning, usually takes place in from five to twenty-four hours. In rare cases pain, vomiting, and purging are slight or wanting. In some of these cases the patient passes at once into a state of collapse, in others the symptoms resemble those produced by a narcotic.

Frequently the progress of the case is not so rapid as stated above. The early symptoms, consisting of burning pain in the throat, œsophagus, and stomach, vomiting, purging, excessive thirst, irregular pulse, coldness of the extremities, and great weakness, last from a few hours to one or two days, when a remission, or even a complete intermission, of some of the prominent symptoms, especially of pain, vomiting, and purging, occurs. After a time, however, the symptoms recur with increased violence, and run the same general course which has been described, death taking place in from two to six or eight days. In some cases an eruption appears on the skin; a result, possibly, of the local action of the arsenic, inasmuch as it is eliminated in part through the glands of the skin. The character of this eruption varies in different cases. It may be petechial, papular, vesicular, or pustular; or there may be a simple diffused redness. Salivation and jaundice have been occasionally observed.

Arsenic has proved fatal when applied to the abraded skin, to ulcerated surfaces, and when introduced into the vagina and rectum. Violent symptoms of poisoning have been produced by its application to the sound skin. The drug is absorbed with great rapidity when inhaled in the form of vapor.

Other Sources of Acute Poisoning.—Next to arsenious oxide, arsenite of copper gives rise to the largest number of cases of acute arsenical poisoning. This compound forms the whole or a part of the pigments known as Scheele's green, Paris green, Schweinfurt or emerald green (aceto-arsenite of copper). When pure, these pigments contain from fifty-five to sixty per cent. of arsenious acid, to which their poisonous properties are mainly due. During the past few years arsenite of copper has been sold extensively under the name of Paris green for the purpose of killing potato-bugs. Owing probably to the ease with which it can be obtained, it has given rise to a considerable number of cases of suicidal poisoning. Many cases of accidental poisoning have resulted from the use of these compounds as pigments. They are employed in the manufacture of artificial flowers and of other articles of dress, the most dangerous of which is green tarlatan; in the manufacture of wall-papers; for coloring children's toys, candles, crayons, etc.; in the manufacture of green glazed papers, which are used so extensively for covering boxes, as wrappers for confectionery and toilet articles, for decorating candy, pastry, and other articles, for lamp-shades, in the form of wafers and labels, and in kindergarten schools. Occasionally these pigments are used as green paints, and they were formerly much resorted to for coloring confectionery and pastry articles. Articles made of card-board, such as concert tickets, playing cards, price cards, etc., are frequently colored with them.

The arsenical pigments more frequently give rise to chronic poisoning than to acute poisoning, but cases of acute poisoning are not infrequent, especially among children, who have put into the mouth papers, toys, water-colors, crayons, etc., which had been colored with them. Formerly acute poisoning often followed the ingestion of candy and other articles of food colored with arsenite of copper; but the pigment is rarely if ever used for this purpose at the present time. Occasional cases of poisoning have been caused by eating articles of food which had been placed upon surfaces

colored with arsenite of copper and had absorbed some of the pigment.

The sulphides of arsenic, if pure, are usually considered harmless. Some experiments of Ossikovszky, however, point to the possibility of the oxidation of the yellow sulphide to arsenious acid under the conditions existing in the intestines. The commercial sulphides usually contain a considerable amount of arsenious oxide, and are, therefore, active poisons. They have been used for criminal poisoning, and orpiment has given rise in several instances to acute poisoning as a result of its use by mistake for other pigments in coloring articles of food. The external application of orpiment as a depilatory has been followed by fatal results.

The arsenites and arseniates of sodium and potassium are more poisonous than arsenious acid, inasmuch as they are more soluble. The arseniates have seldom given rise to poisoning. Several cases of fatal poisoning have occurred among children, as a result of drinking the water in which certain fly-papers (bibulous paper soaked in a solution of arsenite of sodium and subsequently dried) had been placed. Taylor relates cases of poisoning resulting from the use of arsenite of sodium as a cleansing fluid. The external application of arsenical soaps has been followed by eruptions on the skin and by severe symptoms of irritant poisoning.

With the exception of the coppery taste, and the green color of the vomitus and stools in poisoning by arsenite of copper, the symptoms caused by all the above compounds of arsenic are the same as those produced by arsenious oxide.

Fatal Period. — The shortest periods within which arsenic has proved fatal are twenty minutes (Taylor), one hour (Finlay), two hours (Foster, Clegg, Boland), two and one-half hours (Dymock). Death has occurred in from three to six hours in many cases. In some cases life has been prolonged for several days; six days (case of Duc de Praslin), seven (Taylor), twelve (Cormick), sixteen days (Alexander). In one case in which arsenic was applied externally death did not take place till the twentieth day. Two cases are recorded in which death resulted from the secondary effects of the poison after the lapse of two and three years respectively (Belloc, Wepfer). According to Taylor, the average time at which death takes place is twenty-four hours. Woodman and Tidy state that arsenic has proved fatal, in one-half the fatal cases recorded, within nine hours. In non-fatal cases recovery is frequently delayed for many months by disturbances of digestion, affections of the skin, neuralgic pains, anæsthesia, and paralysis of the extremities.

Fatal Quantity.—The minimum fatal dose appears to be in the neighborhood of 0.13 Gm. (2 grs.). Dr. Lachèse places it at from 0.050 to 0.10 Gm. (0.77 to 1.54 gr.); Tardieu at from 0.100 to 0.150 Gm. (1.54 to 2.31 grs.); Taylor at from 0.130 to 0.195 Gm. (2 to 3 grs.), under favorable circumstances. Taylor quotes one case in which 0.13 Gm. (2 grs.), in the form of Fowler's solution (arsenite of potassium), taken in divided doses during five days, destroyed the life of a woman; another in which 0.162 Gm. (2½ grs.), taken in the form of fly-water, was fatal to a healthy girl aged nineteen years. Serious symptoms have been caused, in two or three cases, by 0.13 Gm. Recovery has taken place after doses varying from 3.9 to 62.2 Gm. (ʒ j. to ℥ ij.).

Appearances.—The mucous membrane of the stomach is usually inflamed either over its whole surface or in patches. The color is sometimes deep crimson, more often a brownish-red, and frequently assumes a dotted or striated appearance. There is frequently an effusion of blood beneath the membrane, which is sometimes softened, thin, and easily separated; at other times thickened and corrugated. If the arsenic has been administered in the solid form, portions of it may be found embedded in the thick mucus which adheres to the inner surface of the stomach. Sometimes, in cases of poisoning by white arsenic, the yellow sulphide, formed by the action of the sulphuretted hydrogen evolved during decomposition, is found adhering to the inner surface of the œsophagus, stomach, or intestines. Ulceration of the stomach is very rare, and perforation still rarer. The mucous membrane of the intestines presents appearances similar to those observed in the stomach; but the inflammation of the intestines is frequently limited to the duodenum and rectum. The œsophagus is sometimes highly injected. The appearances in the stomach and intestines are, as a rule, more marked the longer the patient has lived after taking the poison. Cases are recorded, however, in which no pathological appearances were observed in the alimentary tract, although a large dose had been taken, and life had been prolonged for several hours; while well-marked inflammatory appearances have been observed in cases which proved fatal as early as two and three hours after ingestion of the poison. The appearances in the stomach and intestines are the same, whether the poison has been introduced into the system by the mouth or by other channels. Sub-endocardial extravasation, most marked in the left ventricle, about the columnæ carneæ, has been observed (Wilks, Bonavia, McLeod). There is, in arsenic poisoning, a more or less extensive fatty degeneration of the liver, kidneys, heart, muscular tissue of the diaphragm, and epithelium of the glands of the stomach and intestines. In some cases of poisoning the body has been found in a good state of preservation many months and even years after death. To what extent this is due to the arsenic is uncertain, since in some cases of arsenic poisoning decomposition has proceeded very rapidly, while the body has been found remarkably well-preserved in cases of death from other causes.

Absorption and Elimination.—Arsenic is rapidly absorbed and may be detected, after death, in all the organs and tissues of the body. During the past few years there has been considerable discussion with regard to the relative proportion of arsenic contained in the different tissues: most authorities agree in stating that the liver and kidneys usually contain the largest amount. In 1875 Scolosuboff made some experiments on animals, feeding them with a solution of arsenite of sodium, and found that the brain and spinal cord always contained the largest amount of arsenic, in both acute and chronic poisoning. He concluded, therefore, that the paralyses so often observed in cases of arsenical poisoning are the result of changes in the nervous tissue. His results were confirmed by DePoncy and Livon, who also state that the amount of phosphoric acid in the urine is considerably increased, which increase they attribute to a replacement of the phosphorus, in phosphoglyceric acid, by arsenic. Ludwig's results were different. He made many analyses of the organs of persons who had committed suicide with white arsenic, likewise of the organs of dogs which had died from both acute and chronic arsenical poisoning, and found that the liver contained the largest amount of arsenic in all cases; that, in acute poisoning, the kidneys also contained considerable arsenic; while the bones and the brain contained very small quantities. In a later paper, Ludwig states that, in acute poisoning the kidneys may contain a larger proportion of arsenic than the liver; that the muscular tissue always contains more than the brain; and that, in chronic poisoning, arsenic is found in the liver for a longer period than in any other organ. Bergeron, Delens, and L'Hote found, in a case of poisoning by Paris green, seven times as much arsenic in the liver as in the brain; the kidneys and muscular tissue also contained more than the brain. Garnier's investigations also show that the liver is the organ in which arsenic accumulates to the greatest extent, in both acute and chronic poisoning. Recorded analyses, made by Guareschi, Johnson, Chittenden, E. S. Wood, and the writer, confirm the conclusion arrived at by Ludwig, that in poisoning with arsenious oxide the largest quantity of arsenic is found in the liver and kidneys. Chittenden suggests that the form of the poison, whether readily soluble, as arsenite of sodium, or comparatively insoluble, as arsenious oxide, may modify the amount contained not only in the brain but in the muscular tissue; that, when comparatively large amounts are found in these parts, the poison may have been taken in a soluble form. Inasmuch as the arsenic is very unequally distributed through

the muscular tissue, in some cases, while, in others, it is distributed more evenly, he suggests that the distribution through the muscular tissue may throw some light on the time at which the poison was taken. The quantity of arsenic taken appears to have no influence on its distribution.

Elimination commences very soon, and takes place chiefly through the kidneys; in part, however, through the glands of the skin, the mucous membrane of the alimentary canal, and in the bile, saliva, and tears. The time required for complete elimination appears to be, as a rule, about fourteen days; in some cases a longer period is required. Arsenic has been detected in the urine nineteen days (E. S. Wood), twenty days (Maclagan), twenty-one days (Eulenburg), and six and one-half weeks (Gaillard) after the last administration. Chittenden detected traces of arsenic in the organs of a man who died fourteen days after taking arsenious oxide. On the other hand, cases are reported in which death took place within a few days after taking the poison, and yet none could be detected in any part of the body.

Treatment.—The poison should be quickly removed from the stomach by means of emetics, as sulphate of zinc, mustard and warm water, or salt and warm water; or the stomach-pump may be employed. Castor-oil should be administered to remove the poison from the bowels. As a chemical antidote, the freshly precipitated hydrate of iron promises good results, when the arsenic has been taken in solution. It cannot be depended upon when the arsenic has been taken in the solid form. This antidote may be prepared by neutralizing a solution of one of the sesquisalts of iron with magnesia or carbonate of soda. The precipitate thus obtained, having been collected on a muslin strainer or a filter, and hastily washed with water, should be administered very freely. Mattison recommends dialyzed iron, to which common salt has been added to precipitate the hydrate of iron. The after-treatment depends upon the symptoms.

Chronic Poisoning.—This may result from the repeated administration of small doses of arsenic, and is frequently observed, in a mild degree, as a result of the medicinal employment of Fowler's solution (arsenite of potassium). Criminal poisoning, by the administration of small doses of arsenic, is seldom observed. Chronic arsenical poisoning is most frequently caused by the inhalation of the vapors of arsenic, or by the inhalation of arsenical dust detached from wall-papers, or from artificial flowers and other articles of dress. Those who are especially liable to this form of poisoning are persons engaged in the manufacture of various preparations of arsenic, those engaged in industries requiring the use of arsenical compounds, especially manufacturers of artificial flowers and wall-papers, milliners, paper-hangers, persons who wear articles of dress, in the preparation of which arsenical pigments were used, and persons who occupy rooms the walls of which are covered with arsenical papers.

The presence of arsenic in wall-paper was formerly due, almost entirely, to the use of Scheele's and Schweinfurt green as pigments. The dangerous character of these pigments is now so well recognized that they have been replaced, to a great extent, by other and less injurious pigments. Green wall-papers are not, therefore, so frequently arsenical as formerly. At the present time papers of all colors may contain a considerable quantity of arsenic, which is introduced, either with aniline dyes, which frequently contain arsenic as an impurity, or with other colors to which compounds of arsenic have been purposely added by the color-manufacturer, "to make the color work better." Fabrics, also, may contain arsenic, which is introduced with the color; but fabrics, which are colored with non-arsenical colors, are frequently rendered arsenical by the use of arseniate of sodium as a dung substitute, or by the use of compounds of arsenic as mordants.

Symptoms.—The first symptoms are the result of the local action of the arsenic, and consist of irritation of the mucous membrane of the eyes (amounting in some cases to conjunctivitis), intolerance of light, irritation of the nose and throat, dry cough, loss of appetite, nausea, a feeling of uneasiness or pain in the stomach and intestines, and sometimes vomiting and diarrhœa. Frequently these symptoms are not very severe, but in a few cases they have run an acute course, and have resulted fatally. Other symptoms produced by the constitutional action of the poison are headache, sleeplessness, muscular debility, emaciation, depression of spirits, neuralgic pains in various parts of the body, attacks of fainting, muscular tremblings, occasionally convulsions, and sometimes paralysis of the extremities. These symptoms are probably due, in most cases, to the inhalation of minute particles of arsenical dust. It is probable, however, that under certain conditions a portion of the arsenic in arsenical wall-papers is given off in the form of arseniuretted hydrogen, and that the symptoms produced by such papers are sometimes due, in part, to the inhalation of this gas.

All the symptoms described will not be observed in every case. They are subject to many variations, depending especially upon the length of exposure and upon idiosyncrasy. The effect of idiosyncrasy is observed especially in the case of persons exposed to arsenical wall-papers; for the number of those thus exposed, who experience symptoms of poisoning, is comparatively small. In many cases, however, the symptoms have undoubtedly been attributed to other causes, inasmuch as the catarrhal symptoms resemble those of an ordinary cold, while the symptoms of gastro-intestinal irritation, if comparatively mild, may readily be attributed to indigestion. It is possible, too, that some persons may gradually become accustomed to the presence of arsenic and afterward experience no ill effects from the exposure, since it is a well-established fact that the peasants of Styria gradually become accustomed to take internally quantities of arsenic which would be fatal to those unaccustomed to its use.

Workmen who handle preparations of arsenic frequently suffer from eruptions of various kinds on the skin. These eruptions are sometimes very limited in extent, sometimes more diffused, and are developed especially on those parts of the body with which the poison can come in direct contact, as the hands, nose, and face. The poison is sometimes transferred by the hands to the scrotum and penis, and serious ulceration of these parts occurs.

Similar eruptions have been produced by arsenical paper, by playing-cards, the backs of which were colored with arsenite of copper, and by various articles of arsenical wearing apparel, especially stockings, gloves, and hat-linings. Irritation of the skin is sometimes produced by articles of wearing apparel, which upon analysis are found to be free from arsenic. It is uncertain in such cases whether the irritation is caused by the color itself or by some impurity in the color, or by the mordant with which the color is fixed upon the fabric. Very little is known with regard to the action of the pure dye-stuffs upon the skin. The irritation produced by aniline colors is usually attributed to arsenic or to free aniline. It has been stated that corallin and picric acid, when used as dyes for stockings, have given rise to eruptions on the skin. Landrin and Guyot, however, state that pure corallin is perfectly harmless, and it is by no means certain that picric acid has produced all the effects which have been attributed to it. It is not improbable that many dyes may act as irritants to skins particularly susceptible to irritation; but there are reasons for believing that the eruptions, which have been attributed to the non-arsenical pigments, have been caused in many cases by impurities in the pigments, or by the mordants used to fix them upon the fabric.

Treatment.—The source of the poisoning must be removed, and symptoms treated as they arise.

William B. Hills.

ARSENIURETTED HYDROGEN, Poisoning by. This is a compound of arsenic and hydrogen. It is a colorless gas, has a disagreeable odor, resembling that of garlic, and is one of the most poisonous substances known. It

is formed in various ways: as when soluble compounds of arsenic are brought into contact with nascent hydrogen in acid solutions, when arsenious acid or arsenites are brought into contact with nascent hydrogen in alkaline solutions; or when metals containing arsenic are acted upon with dilute sulphuric or hydrochloric acids. Its preparation requires great care on account of its poisonous properties. It has given rise to several cases of poisoning among chemists, who have accidentally inhaled the gas while experimenting with it, or who have inhaled hydrogen gas which had been prepared with arsenical zinc or acid. Within a few years several cases of poisoning have occurred among workmen, who have inhaled the gases, evolved in certain manufacturing processes, in which arsenical materials were employed.

SYMPTOMS.—These generally come on very quickly; sometimes immediately after inhaling the gas. If, however, the gas is largely diluted with air or hydrogen, they may be delayed for many hours. The first symptoms are giddiness, headache, nausea, and vomiting. There are pains in the limbs and in the region of the kidneys. The urine is bloody, contains hæmoglobin (hæmoglobinuria), and is frequently partially, sometimes wholly, suppressed. There is sometimes constipation, but more frequently diarrhœa. The stools are bloody. Jaundice is a prominent symptom. The pulse is usually small and rapid, the temperature increased, the skin sometimes hot and dry, sometimes cold and covered with perspiration. There is great restlessness and anxiety, extreme prostration, a tendency to sleep, and delirium. Death usually takes place in from one to seven days, but has been delayed for two or three weeks. In non-fatal cases recovery is usually slow, requiring from one to three weeks, and in some cases as many months.

FATAL QUANTITY.—The quantity required to destroy life is unknown, but is without doubt very small. An atmosphere containing 0.25 per cent. is fatal to animals (Eulenburg). It has been stated that the quantity which proved fatal to the chemist Gehlen corresponded to no more than 0.0006 Gm. ($\frac{1}{100}$ gr.) arsenic. One-half cubic inch inhaled in forty minutes caused serious symptoms, from which recovery did not take place till the lapse of seven days (Schlinder).

APPEARANCES.—The most constant have been the following: a yellow coloration of the skin and of the tissues of the body in general; injection of the pia mater; a bloody serous fluid covering the convolutions of the brain; a brownish-black fluid exuding from the nose and mouth; bloody extravasations in the pleural cavities; congestion of the kidneys. The tubules of the kidneys have been found filled with blood-globules (Waechter). In a case reported by Coester, the body, sixty hours after death, was so putrid that the structure of the organs could not be made out. The mucous membrane of the stomach has been found inflamed in one case; of a dark slate-gray color in another. Inflammation of the mucous membrane of the small intestine has been observed in a single case.

ABSORPTION AND ELIMINATION.—Arsenic has been detected in the blood and nearly all the organs of the body; also in the urine passed before death.

TREATMENT.—This must be entirely symptomatic. There is no known antidote. The inhalation of dilute sulphuretted hydrogen has been suggested, in order to convert the arseniuretted hydrogen into the insoluble sulphide of arsenic. *William B. Hills.*

ARTERIES, ANOMALIES OF. Arteries are subject to frequent variations of size, origin, and distribution. Some of these are so common that it is difficult to decide what is the normal condition. Many anomalous arteries are merely a persistence of an early fœtal condition, others are reversions to forms of distribution which are natural in the various species of the lower animals, while some are due to an abnormal enlargement or diminution of vessels which naturally exist. I propose in the present article chiefly to describe those anomalies which are important surgically; that is, those which exist in parts liable to diseases which necessitate a surgical operation for their cure or relief. However interesting would be a consideration of anomalies of arteries from a morphological point of view to pure anatomists, I fear the subject is not of sufficient interest to the general profession to justify me in devoting much space to it here.

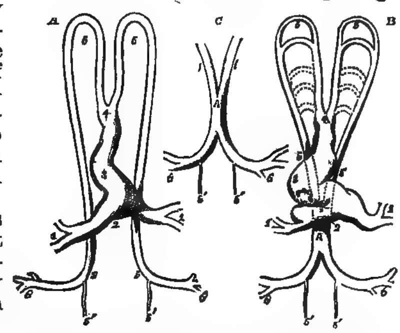

FIG. 264.—Diagrammatic Outlines of Heart and First Arterial Vessels of the Embryo, as seen from the Abdominal Surface. 4, Aortic bulb; 5, 5, the primitive aortic arches and their continuation as the descending aorta. These vessels are separate in their whole extent in *A* (36 to 38 mm. in thickness), but at a later period, as shown more fully in *C*, have coalesced into one tube in a part of the dorsal region. In *B*, below upper 5, the second aortic arch is formed, and farther down the dotted lines indicate the position of the succeeding arches, numbering five in all. (Quain's "Anatomy.")

AORTA.—This vessel is subject to many variations. It may vary in length and position. The summit of the arch has been seen as high as the top of the sternum and as low as the fifth dorsal vertebra. The distance to which it reaches on the spine before dividing into the two common iliacs also varies, the point of division being occasionally as low as the fifth, and as high as the third, or even the second, lumbar vertebra. The aorta has been seen consisting of two closely united tubes, in part or the whole of its course, due to a persistence of the original double aorta of early fœtal life (Fig. 264). The aorta is sometimes very tortuous, of large size, and displaced to one side, especially in old people, but this condition is more due to pathological changes than to congenital malformation.

The main trunks of the *aorta* and pulmonary artery are (4, Fig. 264), both derived from the arterial bulb of the fœtal heart, "and are liable to variations which may be traced to deviations from the natural mode of their septal division and of their union with the left or right ventricles of the heart respectively" (Quain's "Anatomy"). These variations are generally associated with malformations of the heart, and often with patency of the ductus arteriosus. The aortic or pulmonary trunk may be almost obliterated, or the two trunks may communicate freely with one another, owing to the failure of complete septal division; again, their origins may be transposed, the pulmonary artery may arise from the left ventricle and the aorta from the right. A very rare anomaly has been reported where the pulmonary artery and aorta form one stem which arises from a simple heart

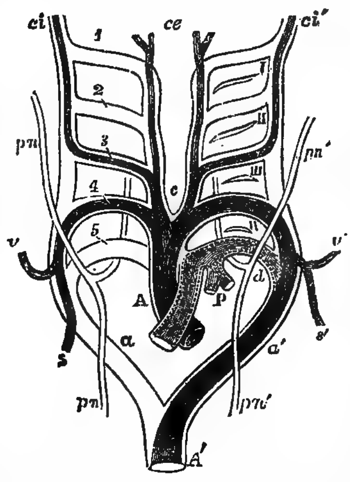

FIG. 265.—Diagram of the Fœtal Aortic Arches, showing their Transformation into the Permanent Vessels of the Mammal. (After Rathke.) The permanent vessels are represented by the deep shading, the pulmonary arteries lighter, the temporary primitive arches in outline only. A, P, primitive aortic stem, divided into A, aortic arch, P, pulmonary artery; *a*, right aortic root; *a′*, left aortic root; *A′*, descending aorta; 1, 2, 3, 4, 5, primitive vascular arches, *pn*, *pn′*, right and left pneumogastric nerves; *v*, *v*, right and left vertebrals; *s*, *s′*, right and left subclavians; *ce*, external carotids; *ci*, *ci′*, internal carotids. (From vol. ii., Quain's "Anatomy.")

like that seen in fishes. A few cases are reported where the descending aorta arose from the pulmonary artery and gave off the left subclavian, the left ventricle only giving off the innominate and left carotid. Most of these varieties are incompatible with life, and are described fully in works on pathological anatomy.

Varieties of the Aortic Arch.—The various anomalies of the aortic arch depend on the mode of development of the fourth and fifth fœtal branchial arches. In man and nearly all mammalia the arch is a left one, produced by the persistence of the fourth left branchial arch (Fig. 265.) In birds the permanent aorta is formed from the right fourth branchial arch; and in reptiles both the right and left fourth branchial arches are persistent. In cases where there is transposition of the heart, and also, of course, of the arch of the aorta, the aorta is a right one, instead of the usual left, and this is owing to the persistence of the right fourth branchial arch, as in birds. The pulmonary artery in these cases is also transposed and is formed from the right fifth arch in place of from the left. Many of these cases have been reported and have been diagnosed during life, the direction of the apex of the heart being toward the right, the apex-beat being felt on the right side between the fifth and sixth ribs. A very good specimen of this anomaly is to be seen in the museum of the Pennsylvania Hospital in Philadelphia.

Occasionally the aortic arch has been observed completely double (Fig. 266), as in reptiles, due to the persistence of both right and left aortic roots (*a*, *a'*, Fig. 265) and the fourth branchial arches, of both sides. The double aorta embraces the trachea and œsophagus, and unites below to form a single trunk on the left side of the spinal column, as in early fœtal life (*B*, Fig. 264).

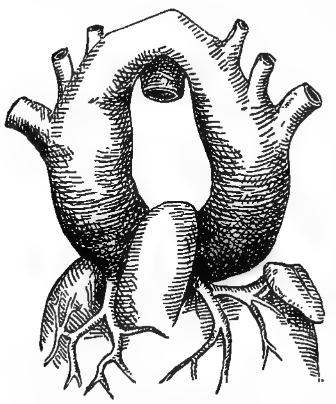

FIG. 266.—Example of a Double Ascending Aorta, from the Arch of which arise Six Branches, Two Subclavian and Four Carotid Arteries. (After Malacarne.)

The aorta may pass to the right of the trachea and œsophagus instead of to the left, and this without the transposition of the heart mentioned above. If we study the fœtal conditions the explanation of this anomaly is easy. It is a persistence of the right fourth branchial arch and aortic root instead of the left (Fig. 264). In these cases the recurrent laryngeal nerve of the left side hooks round the subclavian, and that of the right around the arch of the aorta. In some of the cases of right arch that have been observed the left subclavian arose from the back part of the descending aorta, passed behind the trachea, and reached its usual position in the neck between the scalene muscles. In cases of this kind the first part of the subclavian being absent, owing to the non-development, or rather obliteration, of the fourth left vascular arch, the inferior laryngeal nerve does not hook around it, but goes directly to the larynx, and the vertebral artery may arise directly from the arch.

Variations in Number and Position of the Branches of the Arch of the Aorta.—These variations are very numerous; I shall only mention the most common and important. The branches of the aortic arch may be given off from a single trunk, which forms what is called the anterior aorta. This arrangement is seen in the horse. The commonest abnormal arrangement of the branches is that where the left carotid arises from the innominate; thus only two branches are given off from the arch, the left subclavian and innominate. This is the usual distribution in most of the carnivora. There may be two innominates given off from the arch, each dividing into a carotid and subclavian, as in the bat. Three branches is the normal number arising from the arch in man, apes, and a few other animals. Occasionally we see three branches arising from the arch in a different way from the normal. We may have the two subclavians arising separately, and the two carotids arising from a common stem between them. This is the normal disposition in some cetacea. Sometimes all four vessels arise separately from the arch. Again, the left vertebral may arise from the arch, while the other branches preserve the normal arrangement, or there may be five branches given off separately, viz., the two subclavians, two carotids, and left vertebral. As many as six branches have been seen to come off from the aortic arch. This occurs when, in addition to the above-mentioned five branches, the right vertebral is also given off. A curious anomaly, and one which is interesting from its rarity and manner of development, is that form of arch where the right and left carotids and left subclavian arise separately from the arch, and the right subclavian arises from the back part of the descending aorta, passes behind the trachea and œsophagus and ascending portion of the arch, and reaches its normal place between the scalene muscles (Fig. 267). In this case the right inferior laryngeal nerve, instead of hooking round the subclavian, passes directly to the larynx. The subclavian here represents the persistent right aortic root, and the right fourth branchial arch is obliterated (see Fig. 265). Some years ago I met with a curious anomaly having somewhat this character. I looked upon it as a double subclavian. The right subclavian was given off as usual from the innominate, but was joined in the second part of its course, between the scalene muscles, by a small branch which arose from the back part of the descending aorta. I considered this a case of persistence of the fourth right vascular arch, and also of the right aortic root (Fig. 268). (For a complete description of the very many varieties of the arch of the aorta, see Turner on "Varieties of the Arch of the Aorta," in *Brit. and For. Med.-Chir. Rev.*, 1862; Henle's "Anatomy," vol. iii.; Hyrtl and Professor Struthers.)

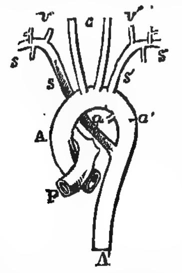

FIG. 267.—The Right Subclavian Artery displaced or proceeding from the Right Aortic Root. A, A', ascending and descending portion of the thoracic aorta; *a*, right aortic root persisting as the subclavian artery; *a'*, left aortic root; P, pulmonary artery. (Quain's "Anatomy.")

INNOMINATE, OR BRACHIO-CEPHALIC.—This artery occasionally varies as to the point of its division. In some cases it divides above the sterno-clavicular articulation, and in others considerably below it. When there is a high division, there is danger of its being wounded in tracheotomy, especially in those cases where the artery inclines to the median line. In cases of ligature, however, the operation would be much facilitated by a high division, and rendered much more difficult by a low one.

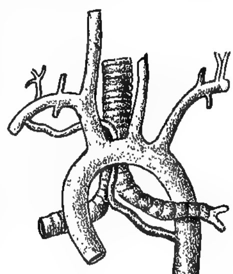

FIG. 268.—Right Aortic Root persisting as a Small Branch which connects the Descending Aorta with the Subclavian. May be regarded as an example of double subclavian.

The *thyroidea ima* or *middle thyroid* (Fig. 269) is not infrequently given off from the innominate, and ascends to its destination in front of the trachea. When present it would complicate the operations of tracheotomy and excision of the thyroid gland. In observations made by myself on two hundred and fifty subjects, I found that this artery occurred twelve times, or once in 20.83 cases. Richard Quain, in his valuable work on the arteries, found it nine times in two hundred and ninety-one subjects, or once in 32.33. It is sometimes of large size,

dividing into two branches, one of which goes to each lobe of the thyroid gland.

This artery sometimes arises from the right common carotid, and rarely from the arch of the aorta between the left carotid and innominate.

Common Carotid Arteries.—These vessels may vary in their origin and place of division. The *right carotid* occasionally arises directly from the arch of the aorta either alone or with the left carotid. In the latter case the artery, to reach its usual position on the right side, crosses the trachea above the upper border of the sternum, a fact worth remembering in connection with the operation of tracheotomy. It may arise above or below the sterno-clavicular articulation, according as the innominate is longer or shorter than usual. The *left carotid* varies more frequently in origin than the right, as it is derived from the innominate in about one case in nine. It may also arise from the arch in common with the right carotid.

Place of Division.—The common carotid often varies as to its place of division. The normal dividing point is opposite the upper border of the thyroid cartilage, but it sometimes divides as high up as the hyoid bone, and as low down as the cricoid cartilage. Morgagni reports a case where it divided at the root of the neck. Cases are recorded where it did not divide at all, one or other of its main branches being absent. I have occasionally seen this artery give off the superior thyroid and ascending pharyngeal before its division, and also a small laryngeal. I also once saw the left carotid giving off the left vertebral.

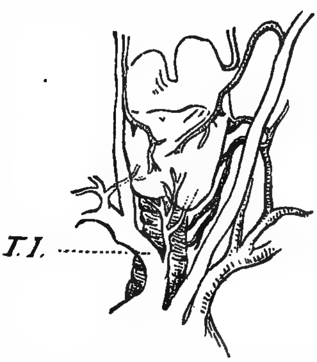

Fig. 269.—Showing a Middle Thyroid Artery arising from the Innominate and running up the Front of the Trachea to supply the Thyroid Gland. (From R. Quain, slightly altered.)

External Carotid and its Branches.—As mentioned above, the origin of the external carotid varies considerably. It has in rare cases been noticed arising from the innominate and even from the arch of the aorta itself. Absence of this artery has been met with, the branches arising at varying intervals from a common trunk, representing both internal and external carotids. The artery sometimes passes between the digastric muscle and stylohyoid. I have in one case seen it pass up to the parotid gland superficial to both the posterior belly of the digastric and the stylohyoid, instead of behind them.

The origin of the branches varies considerably; they may be crowded together at the commencement of the vessel, or at a point higher up. Sometimes they arise from the main trunk at nearly regular intervals, and occasionally we find several branches arising from a single stem. Accessory arteries may arise from the external carotid, such as the accessory superior thyroid and accessory ascending pharyngeal. The sterno-mastoid, which usually arises from the occipital, occasionally arises from the main trunk, and when this occurs the hypoglossal nerve hooks around this small branch instead of around the occipital. In consequence of the lower origin of the sterno-mastoid, the nerve in such cases passes lower down the neck before crossing the vessels to reach the hyoglossus muscle.

Superior Thyroid.—This vessel may be very small or absent, its place being taken by the artery of the opposite side and the inferior thyroid of the same side. It sometimes arises from the common carotid. The *crico-thyroid* may be of considerable size, and its *superior laryngeal* branch may arise from the main trunk, or pierce the thyroid cartilage instead of the thyrohyoid membrane, as is the case in many mammals. Mr. Walsham ("St. Bartholomew's Hosp. Rep.," 1880) has several times met with a large branch from the superior thyroid crossing the trachea between the cricoid cartilage and isthmus of the thyroid. He once wounded it in performing tracheotomy.

Lingual.—This artery often arises in common with the facial, and occasionally with the superior thyroid. Instead of passing beneath the hyoglossus muscle it has been seen to pierce it.

In some rare cases it has been absent, and its place has been taken by a branch from the internal maxillary. Its place has been taken also by a branch from the facial, the submental. Its sublingual branch is occasionally derived from the facial. The hyoid branch is often wanting, and in such cases the hyoid branch of the superior thyroid takes its place. The lingual sometimes gives off the submental and ascending palatine artery.

Facial.—This artery is very variable in size and also in extent. When the facial is deficient its place is taken by the transverse facial, internal maxillary, or ophthalmic, most frequently the first-mentioned.

Occipital.—This artery usually arises opposite the facial, but its place of origin may be above or below this point. Sometimes it is derived from the internal carotid or the ascending cervical branch of the inferior thyroid. It occasionally passes to its destination superficial to the trachelo-mastoid muscle, or it may pierce the sterno-mastoid and splenius capitis muscles. R. Quain mentions a case where it passed superficial to the sterno-mastoid muscle. It not infrequently gives off the posterior auricular and ascending pharyngeal.

Posterior Auricular.—Often a branch of the occipital; sometimes of small size, ending in the sterno-mastoid muscle.

Ascending Pharyngeal.—Varies greatly in its place of origin; may arise from the internal carotid, occipital, or a linguo-facial branch. It is occasionally double.

Superficial Temporal.—This vessel is very often tortuous, especially in the aged.

The *transverse facial* is occasionally of large size, and takes the place of the facial. It is sometimes double.

Internal Maxillary.—This artery frequently arises in common with the temporal. R. Quain has observed it in two instances arising from the facial, "from which it coursed upward, to pass beneath the ramus of the maxillary bone in the usual situation."

It very frequently is covered by the external pterygoid muscle, instead of lying superficially to that muscle. It sometimes perforates the external pterygoid, and rarely the internal. It may replace the facial by a branch from the posterior dental, buccal, or infraorbital artery.

Internal Carotid and its Branches.—This artery in the neck is occasionally very tortuous. It has been known to be absent, its place being taken by the artery of the opposite side or by a branch from the internal maxillary. It is sometimes very small, smaller than the vertebral (Hyrtl). The ascending pharyngeal, occipital, lingual, or transverse facial may arise from the internal carotid.

A large communicating branch has been seen going from this artery, while in the cavernous sinus, to the basilar artery; in such a case the posterior communicating branch is wanting. The posterior cerebral not infrequently comes off from one of its branches, the posterior communicating.

Ophthalmic Branch.—This has been seen to come off from the middle meningeal artery. Occasionally the middle meningeal comes off from the ophthalmic. The ophthalmic may, by its nasal branch, supply a deficiency in the facial.

Cerebral Arteries.—The *anterior cerebral* of one side is often much larger than that of the other. In some rare cases the two anterior cerebral arteries are united into a common trunk, like the basilar. The *anterior communicating* artery is sometimes double; I have once seen it treble. It is often very short. The *posterior cerebral* may arise from the internal carotid by a large posterior communicating. It has been seen by Hyrtl to give off the middle cerebral.

The *posterior communicating* artery occasionally comes off from the middle cerebral instead of from the internal carotid.

SUBCLAVIAN.—The varieties of origin of this artery have already been mentioned in the account of the anomalies of the arch of the aorta and innominate artery. It is generally given off from the innominate on the right side, opposite the sterno-clavicular articulation, but occasionally the innominate reaches nearly as high up as the cricoid cartilage before it divides, and in these cases the artery would be at an unusually high level. The highest part of the artery is the second portion, and it is normally about 1.2 to 2.7 centimetres (one-half to three-quarters of an inch) above the clavicle, with the shoulder depressed, but not infrequently it may be below, or on a level with, the clavicle, and sometimes, especially on the right side, it may be placed as high as 3.7 centimetres (one and a half inch) above the level of the clavicle. It may, in those rare cases where a cervical rib is attached to the seventh cervical vertebra, pass over this rib in place of the first dorsal, and be raised fully two inches above the clavicle. I have seen this occur once in two hundred and fifty subjects examined. In the living, when this condition exists, it may be, and has been, mistaken for aneurism. Sir James Paget has diagnosed this anomaly four times during life. It is obvious that the height to which the artery reaches is important in cases where ligature is necessary. The cases for which ligature is undertaken are chiefly those of aneurism of the axillary artery, where, in consequence of the condition of parts, the shoulder is elevated. If the artery should be at an unusually low level, or even just behind the clavicle, the operation, as may be conceived, would be rendered extremely difficult.

The third part of the artery, in thin people with small muscles, is very superficial, but in stout, muscular individuals is very deeply placed. Dupuytren says, "The third part of the subclavian lies near the skin in those who are thin and have slender and long necks, with lean and pendent shoulders; it is, on the contrary, deeply hidden in persons who have short, thick necks and muscular shoulders."

Occasionally the subclavian artery pierces the scalenus anticus instead of going behind it, and more rarely passes entirely in front of the muscle; of the first variety I have seen five cases in two hundred and fifty subjects (three on the left and two on the right side); of the second, in the same number of subjects examined, I have seen only one example.

The vein may pass with the artery behind the anterior scalenus, and in very rare cases their normal positions may be reversed. The trapezius may cover the third part of the subclavian, or it may have in front of it the omohyoid muscle. These conditions, however, will be more fully described under Anomalies of Muscles.

Variations of Branches.—It is important, surgically speaking, that the position of the various branches given off from the subclavian should be considered.

The branches given off from the first part do not, as a rule, vary much in their arrangement, but several may be transferred to the second or third portions. The left vertebral may arise from the arch of the aorta instead of from the first part of the left subclavian, and the branches of the thyroid axis may be given off separately.

The first part of the right subclavian, having been occasionally ligated, it is necessary to know at what distance from the innominate the branches arise. In the majority of cases this is from 1.25 cm. (half an inch) to 2.4 cm. (one inch) (R. Quain); but it often exceeds this, and is frequently 2.4 cm. (one inch) to 3.8 cm. (one and three-fourths inch). In a small minority of cases the distance is under 1.2 cm. (half an inch).

In the *second portion of the artery*, one branch, as a rule, is given off, the superior intercostal; occasionally no branches are seen here, and again, not infrequently, two or three.

The *third portion*, in a little more than half the cases, gives off no branch, in a little less than half, one branch, occasionally two, and in very rare cases three and four.

Vertebral Artery.—Origin: The right vertebral, in those rare cases where the right subclavian arises from the arch of the aorta, is given off from the common carotid of the right side. The right vertebral has been seen coming from the arch.* The left vertebral not infrequently is given off from the arch of the aorta, generally between the left carotid and left subclavian. I have seen this arrangement twelve times in two hundred and fifty subjects. I have once seen it come off from the left common carotid. The vertebral has been seen with two, and even three roots (R. Quain).

Course: This vessel may fail to enter the transverse process of the sixth cervical vertebra, but continue up the neck between the inferior thyroid artery and vein to enter the transverse process of any of the vertebra from the fifth to the second. It is not uncommon for it to enter the transverse process of the fourth or fifth vertebra, but it is only very occasionally that it passes up as high as the third and second before entering the foramen. Again, it may enter the transverse process of the seventh cervical vertebra, instead of the sixth.

Size: The left vertebral is frequently much larger than the right, especially in those cases where it is given off directly from the arch of the aorta. Sometimes the vertebral is nearly as large as the common carotid, at other times as small as the ascending cervical branch of the inferior thyroid.

Branches: The vertebral may, as a very rare occurrence, give off the inferior thyroid or superior intercostal artery. I have seen two examples of the first variety occurring on both sides of same subject. Its inferior cerebellar branch is frequently absent on one side.

The *thyroidea ima* has been observed in rare cases to come off from the right subclavian.

The upper end of the vertebral artery occasionally divides into two branches, which unite a little higher up, thus forming a loop through which pass filaments of the hypoglossal nerve. I have seen this anomaly in two instances.

Thyroid Axis.—This trunk occasionally arises beyond the scalenus anticus muscle (according to R. Quain twice in two hundred and seventy-three cases). It not infrequently gives origin to the internal mammary. It is sometimes absent, its branches being given off separately from the subclavian.

Inferior Thyroid.—This artery frequently arises as an independent branch from the subclavian. It has been seen to arise from the common carotid, and not unfrequently from the vertebral. It varies considerably in size, and when small its place is taken by the superior thyroid. In cases of enlarged thyroid gland (bronchocele) it is often nearly as large as the carotid. Two inferior thyroids have been found on the same side, one having the normal course beneath the carotid artery, and the other reaching its destination by passing superficially to that vessel (Fig. 270). Its branches of division are closely connected with the recurrent laryngeal nerve, which may pass beneath or above them, a point to be borne in mind in extirpation of the thyroid gland. The inferior thyroid may be wanting altogether, its place being supplied by an enlarged superior thyroid of the same side.

The *ascending cervical* branch of the inferior thyroid may be derived directly from the subclavian or one of its branches. It is occasionally of large size, and may take the place of the occipital.

Supra-scapular.—This artery is usually derived from the thyroid axis, but not unfrequently has a different origin. It is often given off directly from the subclavian. It may be given off from the internal mammary. I have several times seen it derived from the subscapular and also from the axillary. It is often very small.

Transverse Cervical.—This artery when given off from the thyroid axis divides into two terminal branches, viz.,

* Mr. A. M. Paterson (Jour. Anat. and Phys., April, 1884) records a case of right vertebral arising from the aortic arch beyond the left subclavian, and reaching the vertebro-arterial canal by passing behind the trachea and œsophagus; in fact, following exactly the course of the subclavian when it arises from the back part of the arch, as figured above. Mr. Paterson regards this anomaly as a persistence of the right aortic root, with obliteration of the connection between the subclavian and vertebral arteries where they cross.

Arteries.

the superficial cervical and posterior scapular. Very often the superficial cervical, only, is given off from the thyroid axis, the posterior scapular coming off as a separate branch from the second or third part of the subclavian, rarely from the first part. It is well, when ligaturing the third part of the subclavian, to remember that the posterior scapular comes off from it, about once in every three cases. When the posterior scapular artery is given off from the third part of the subclavian I have not infrequently seen it pierce the fibres of the scalenus medius muscle, and occasionally go between the cords of the brachial plexus. The posterior scapular artery may be given off from the axillary, or it may end near the scapula in a small branch, its place being supplied by branches from the suprascapular. The superficial cervical may come off from the subclavian as a separate branch, the posterior scapular alone being derived from the thyroid axis. When the posterior scapular is a branch of the third part of the subclavian it often gives off a large branch to supply the trapezius, which represents the

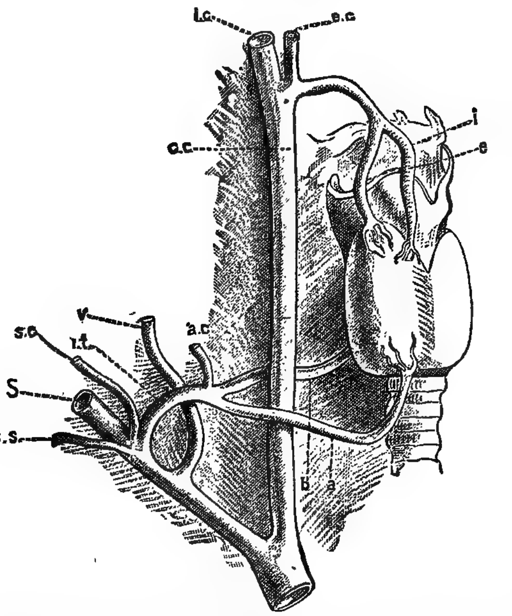

FIG. 270.—Inferior Thyroid Artery dividing into Two Branches, one of which (a) passes in front of the carotid sheath, the other (b) behind it. (Anderson: *Jour. Anat. and Phys.*, vol. xiv.)

greater part of the superficial cervical, the latter artery in such cases being very small or absent.

The transverse cervical artery is occasionally given off from the subclavian as a separate branch.

Internal Mammary.—This is a large and very regular branch of the subclavian, generally arising from the lower part opposite the vertebral. It may arise from the thyroid axis or innominate, or even from the arch of the aorta. It may also form a common trunk with either of the scapular arteries, and be given off from the second or third part of the subclavian. Hyrtl describes a case where the trunk of this artery crossed in front of the fifth right costal cartilage, coming out of the thorax through the fourth interspace and re-entering it by the fifth.

A branch is sometimes given off from the upper part of the internal mammary, called by Henle the *A. mammaria interna lateralis,* which crosses the inner surface of the upper four to six ribs and intercostal spaces at right angles, about midway between the spine and sternum, anastomosing in its course downward and outward with the intercostal arteries. In penetrating wounds of the thorax, fractured ribs and other injuries, this lateral branch might be wounded and give rise to dangerous hæmorrhage. It might also be wounded in the operation for evacuating an empyema.

Superior Intercostal.—Sometimes arises from the thyroid axis or vertebral. May be of considerable size, and supply three or four intercostal spaces. It in some cases passes between the neck of the first or second rib and the corresponding transverse process of the dorsal vertebra. It is very rarely absent.

Deep Cervical.—This artery is generally a branch of the preceding but occasionally is derived directly from the subclavian, in the proportion of 1 in 20 subjects (R. Quain). In rare cases it arises from the posterior scapular and internal mammary. It is not infrequently of small size, its place being taken by the deep cervical branch of the occipital, a branch of the inferior thyroid, ascending cervical or a posterior cervical branch of the transverse cervical (Henle).

It may pass between the transverse processes of the fifth and sixth cervical, first and second dorsal, or second and third dorsal instead of between the seventh cervical transverse process and first rib.

There is sometimes an accessory branch accompanying it.

AXILLARY ARTERY.—The most important anomaly of this vessel is its early division into two trunks, one of which may give off all or most of the branches, or may be a high origin of the radial, ulnar, or even the interosseous artery (Fig. 271). When one of the trunks gives off all or most of the branches it is nearly always surrounded by the brachial plexus of nerves and embraced by the two heads of the median. The branches given off from this common stem may vary. I have seen it give origin to the acromial thoracic, long thoracic, anterior and posterior circumflex, subscapular, and one or both of the profunda arteries of the arm; the anterior and posterior scapular with the subscapular arteries not infrequently come from a common stem. This arrangement of the branches of the axillary occurs normally in many animals, *e.g.*, the lemur, tapir, peccary, dolphin, etc., and much resembles that which takes place in the lower extremity, viz.: the common femoral dividing into a superficial and deep branch, and the deep giving off all the branches, and the superficial going down the extremity branchless. According to Richard Quain, this variation occurred twenty-eight times in five hundred and six arms examined. I have only met with it fifteen times in five hundred arms in which the arrangement of the axillary was observed. Quain gives the proportion of cases in which one of the arteries of the forearm is derived from the axillary as 23 in 506; Gruber, 21 in 1,200. I have found this condition to exist 12 times in 500 arms examined.

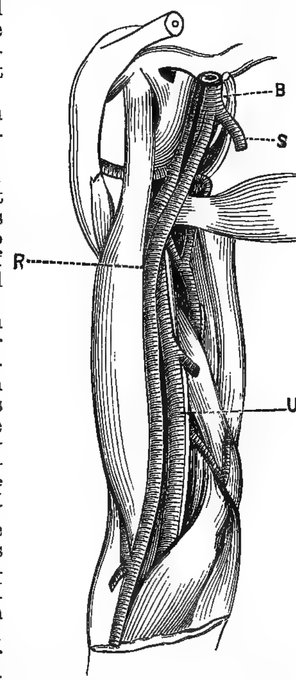

FIG. 271.—Origin of Radial (R) from the Axillary. (After Reeves.)

The radial is the branch most frequently given off in these cases, next the ulnar, and, very rarely, the interosseous. I have only once seen the interosseous arise from the axillary.

An aberrant artery is occasionally found arising from the axillary; it generally courses down the arm alongside the brachial, which it joins near the elbow. Sometimes this aberrant vessel joins the radial, ulnar, or interosseous

artery near the wrist. One remarkable case came under my observation some years ago in which this aberrant artery passed down the arm superficial to the fascia, in the forearm followed the course of the median nerve, communicated with the radial by several transverse branches, and finally ended by taking the place of the superficial volar, completing the superficial palmar arch (Fig. 272).

The most constant branch of the axillary is the long thoracic or external mammary; this, or a representative of it, is seen nearly always running along the lower border of the pectoralis minor muscle; it, however, not infrequently arises from the thoracic axis and occasionally from the subscapular. The subscapular and circumflex branches frequently arise together. The dorsalis scapulæ, instead of being derived from the subscapular, may arise directly from the axillary.

The posterior circumflex occasionally fails to enter the quadrilateral space (formed by the humerus, subscapularis muscle, long head of triceps, and teres major), but reaches the deltoid muscle by winding round the lower border of the tendons of the latissimus dorsi and teres major muscles.

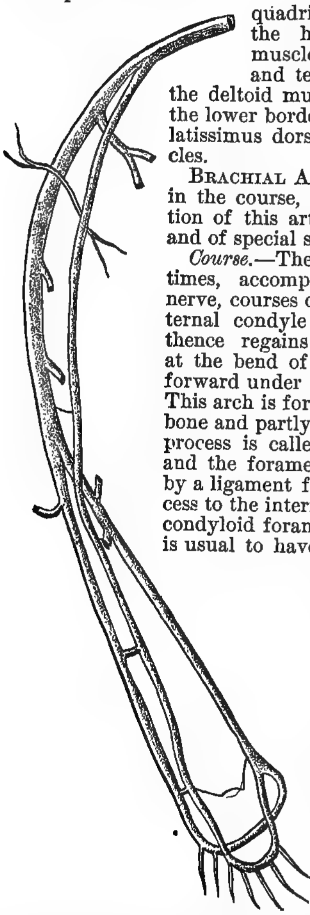

FIG. 272.—Example of an Aberrant Artery from Axillary, going to complete the Superficial Palmar Arch, taking the Place in the Hand of the Superficial Volar.

BRACHIAL ARTERY.—The variations in the course, relations, and distribution of this artery are very numerous and of special surgical interest.

Course.—The brachial artery sometimes, accompanied by the median nerve, courses down the arm to the internal condyle of the humerus, and thence regains its normal position at the bend of the elbow, by passing forward under a fibrous or bony arch. This arch is formed, usually, partly by bone and partly by ligament; the bony process is called the supra-condyloid and the foramen, which is completed by a ligament from the tip of the process to the internal condyle, the supracondyloid foramen. In these cases it is usual to have a high origin of the pronator radii teres muscle from the supra-condyloid process. This arrangement is said to be more common in dark races, and is the normal one in all the cat tribe and in monkeys, lemurs, and sloths. In these animals the foramen is nearly always completed by bone, and affords protection to the median nerve and artery during flexion of the fore-limb, and also affords them a more direct course to the fore-limb. In man the artery may occasionally take this course without there being present a supra-condyloid process; there may be only a high origin of the teres muscle.

Division.—I have once seen the artery divide near its commencement into two branches which unite to form one trunk near the bend of the elbow, from which the ulnar and radial arteries are given off at the usual place (Fig. 273).

In 481 arms examined by R. Quain a high division was found 64 times, a low division (that is below usual place) only once. Gruber, in 1,200 arms examined, found a high division in 82. In 500 arms examined by myself, I only found a high division in 27, and in one case the brachial divided below the pronator teres.

Adding to these the cases where the division takes place in the axilla, in 481 arms examined by Quain, 2 arteries existed in the arm in 94 cases, or 1 in about 5⅓. My statistics are quite different from the above, and I cannot account for the great diversity. The same class of people were examined, and they were of the same race. In 500 arms I found that 2 arteries existed in only 43 cases. This is made up as follows: division of axillary, 12; division of brachial, 27; aberrant arteries, 4, total, 43, or 1 in 11.6 cases. W. Gruber, in 1,200 arms, found a high division in 103, or one in 11.6, the same proportion exactly as in my own cases.

The point of division is in most cases in the upper third of the arm. It is also seen in the middle and lower thirds, but much less frequently. The artery which is given off thus prematurely is generally (three cases out of four) the radial; this vessel is most frequently to the ulnar side, and subsequently crosses to the radial.

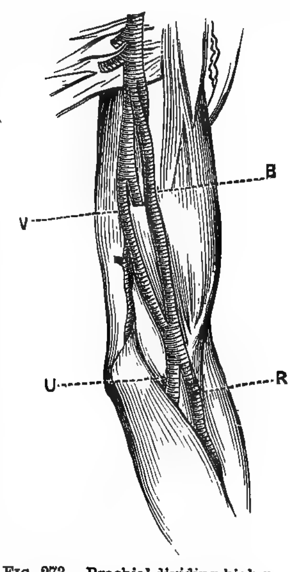

FIG. 273.—Brachial dividing high up, reuniting at Elbow and then almost immediately dividing into the Radial and Ulnar. V, vas aberrans. (After Reeves.)

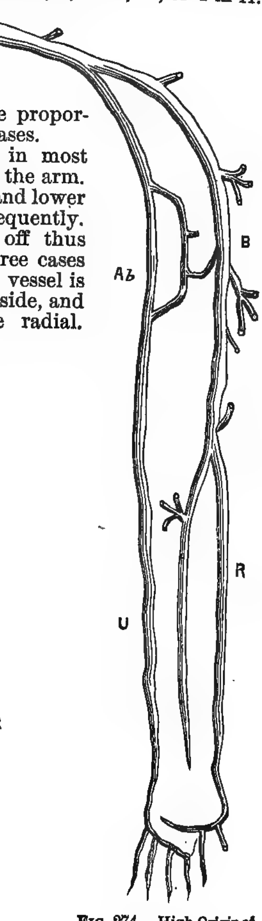

FIG. 274.—High Origin of the Ulnar Artery (U). *Ab*, aberrant artery; R, radial, giving off the interosseous arteries.

Next in frequency comes the ulnar, which often, in these cases, passes superficially down the forearm and gives off no branches, the interosseous coming from the radial (Fig. 274). In rare cases the interosseous is the branch having the high origin (Fig. 275), and still more rarely it is a vas aberrans.

Three branches have been seen in the arm, viz., the radial, ulnar, and a vas aberrans.

The *position of the two branches* in the arm when a high division occurs is of surgical importance. They are usually in the ordinary position of the brachial trunk and lie close together, but the radial, as mentioned above, often arises from the inner side, and, after accompanying the large vessel for some distance, crosses over it at the bend of the elbow.

The *ulnar artery*, when having a high origin, may incline toward the internal condyle; this, however, only occurs when it nears the elbow. When there is a high division of the brachial the ulnar-interosseous branch may

pass through the supra-condyloid foramen mentioned above, and under a high origin of the pronator teres.

The *aberrant arteries* which are given off occasionally, are long, slender arteries, which are derived from the brachial or axillary, and end by joining the radial most frequently and sometimes the ulnar and interosseous. They are loop lines, so to speak, and in cases of ligature of the brachial, their occasional occurrence must be borne in mind by the surgeon (Fig. 276). The two arteries in the arm are in some instances connected together by anastomosing transverse branches. These branches may number two or three, or even four.

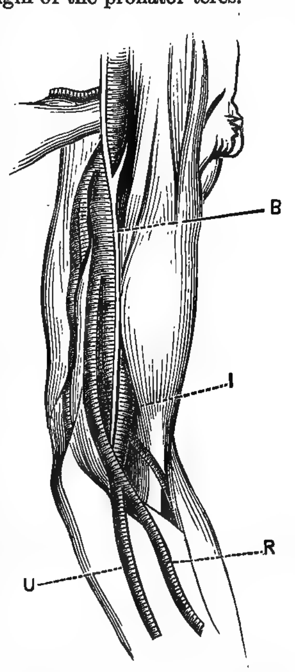

FIG. 275.—Anterior Interosseous (I) given off from the Brachial high up. (After Reeves.)

A *median artery* has been described as arising from the brachial and passing down over the muscles of the forearm and supplying the fingers to which is distributed the median nerve.

The brachial artery may in some part of its course (more frequently near the elbow) be covered by a muscular slip. The median nerve sometimes passes behind instead of in front of the artery, especially in those cases where the two heads embrace a common trunk from which the axillary branches are given off.


FIG. 276.—Aberrant Artery (3) separating from the brachial (1) at the middle of the arm, passing with the median nerve (*d*) through the internal intermuscular septum and joining the regular ulnar (4) lower down. (Quain.)

Superior Profunda.—This is occasionally derived from a trunk common to it and several of the axillary branches, as mentioned above. It not uncommonly arises with the circumflex, and occasionally gives off the inferior profunda.

Inferior Profunda.—This is often absent. It is frequently united with the superior profunda.

Anastomotica Magna.—Frequently of small size; its place is sometimes taken by the inferior profunda.

RADIAL ARTERY.—*Origin:* I have found that the radial has a high origin (Fig. 277) in 1 case in 21, but Quain reports the high origin to occur as often as 1 in 8. Gruber in 440 arms examined found the radial had a high origin in 26, or about 1 in 17 cases.

Course.—The radial only very occasionally deviates from its usual course in the forearm. It has been found lying superficial to the fascia of the forearm, and the semilunar fascia of the biceps. It, in rare cases, courses down the forearm on the surface of the supinator longus instead of along its inner border. It not infrequently is superficial to the tendons of the extensor muscles of the thumb. It is occasionally joined by a vas aberrans. It may leave the front of the forearm near its middle, its place being taken by an enlarged superficial volar. This would cause a weak wrist-pulse.

Size.—It does not vary often in size. It is, however, sometimes much smaller than usual, its place being, to a considerable extent, taken by some other vessel, as the ulnar and anterior interosseous.

The radial has been described as absent by some anatomists. Quain never saw a case of absence of this artery, but such a case is described by Professor Otto.

Branches.—Radial recurrent: This vessel is sometimes of large size, or it may consist of several small branches. When the radial has a high origin the recurrent branch is given off from the ulnar-interosseous trunk.

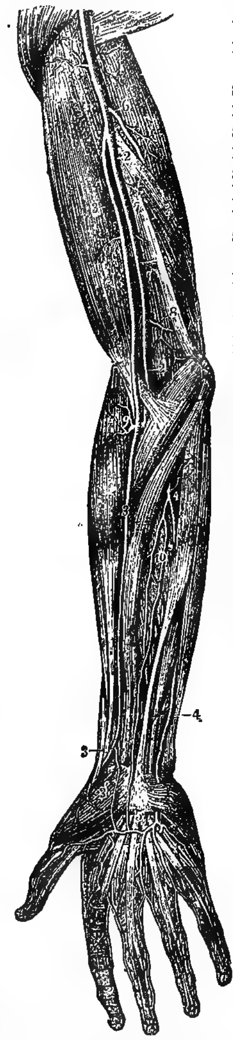
FIG. 277.—Dissection of Right Arm. Showing an example of high separation of the radial artery (3) from the brachial (2); a large median artery (10) is seen in forearm. (From Quain's "Anatomy," after Tiedemann.)

Superficial volar: Very often of small size, so small that it terminates in the muscles of the thumb, and does not complete the superficial palmar arch. It is occasionally entirely absent. It may be of large size and furnish several digital branches (Fig. 278), and it may arise much higher than usual.

I once saw it arise as high as the middle of the forearm, and it was quite as large as the radial, from which it was derived; this is the normal arrangement in some monkeys.

The first dorsal interosseous is, in some cases, of large size, and may supply several digits and end by completing the superficial arch.

The *carpal* and *dorsal interosseous* branches are often of very small size, their place being taken by the perforating arteries.

ULNAR ARTERY.—*Origin:* Quain found that this artery deviated from the usual origin in 1 case in 13, Gruber 1 in 29, myself 1 in 37.

Where the origin of the ulnar is unusual, it most commonly arises from the brachial in the arm, and less commonly from the axillary. In one case out of five hundred I found it coming off from the brachial below the pronator radii teres. In this case there was, of course, a low division of the brachial.

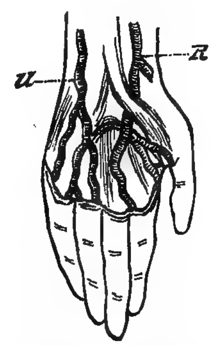

FIG. 278.—No Distinct Superficial Arch. Large superficial volar supplying thumb and index-finger with half middle-finger, and rest supplied by ulnar. (Reeves.)

Course.—In the forearm this artery is much more subject to variation than the radial. When it has a high origin it nearly always courses down the forearm superficial to the muscles, but beneath the fascia; but cases occasionally occur where it is immediately beneath the skin and superficial to the fascia (Fig. 279). When the

ulnar is superficial, it, as a rule, gives off no branches in the forearm, these being given off from the radial—interosseous trunk—or the interosseous itself, which is invariably given off from the radial. The ulnar, in rare cases, has this superficial course when it arises in its usual situation.

Interosseous Artery.—This artery, in rare cases, arises from the axillary or brachial artery (Fig. 275), and gives off the recurrent radial and ulnar arteries. The anterior and posterior interosseous may arise separately from the ulnar.

Median Artery (Fig. 280).—This branch, which accompanies the median nerve, is ordinarily of small size, but occasionally it is developed into quite an important vessel. It is usually derived from the anterior interosseous, but sometimes from the

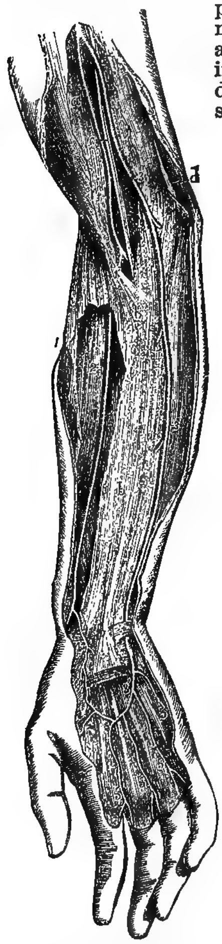

FIG. 279.—Abnormal Superficial Ulnar Artery (3, 3′), rising higher than usual from the Brachial. (Quain's "Anatomy," after R. Quain.)

FIG. 280.—Dissection of Left Arm. Showing an enlarged median artery (5) which replaces the radial (2) and ulnar (3) arteries in the supply of the palmar digital arteries to half the fingers. (From Quain's "Anatomy," after Tiedemann.)

ulnar, and, in rare cases, it has been found coming from the axillary or the brachial. It accompanies the median nerve and reaches the hand beneath the annular ligament, but, according to Tiedemann, sometimes passes over the ligament. It may complete the palmar arch, or be distributed as digital branches to certain of the fingers, generally those supplied by the median nerve, which it accompanies. In the cases I have observed, the latter arrangement was the more frequent. I have occasionally seen this artery pierce the median nerve.

ARTERIES OF THE HAND.—The arteries of the hand are subject to many variations.

The superficial palmar arch is sometimes entirely wanting. It has been occasionally seen double. In the majority of cases the superficial volar branch does not complete the arch, but it is completed often by a large branch from the radial, which emerges between the thumb and forefinger, and I have sometimes seen it completed by a large branch from the radial, which, after coursing over the back of the hand, emerges on the palm between the index- and middle-fingers. The arch is also often completed by a transverse branch, which comes from the muscles of the thumb and is derived from the princeps pollicis or radialis indicis branch of the radial (Fig. 281). A median artery may complete the arch (Fig. 282), or it may go to the digits on the radial side, and the ulnar to the digits on the ulnar side, and no regular arch be formed. The superficial volar sometimes has this arrangement (Fig. 278).

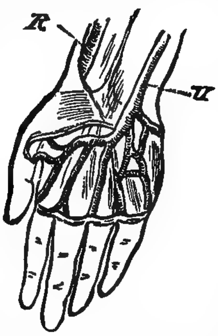

FIG. 281.—Superficial Arch formed entirely by the Ulnar and joining the Princeps Pollicis Artery. (Reeves.)

The superficial arch may be very small and some of the digital branches be wanting, or it may be very large, supplying all the digital branches, both superficial and deep.

The deep arch is occasionally formed by the ulnar. It is sometimes so deficient that the digital arteries are derived from the superficial arch. A large metacarpal branch on the back of the hand may give off the digital branches.

RENAL ARTERIES.—Now that the operation of nephrectomy has become so common, the variations of these arteries have been rendered important surgically. Professor Macalister has lately (*Journ. Anat. and Phys.*, vol. xvii.) reported most of the anomalies of the renal artery.

The renal artery may be replaced by two, three, four, and even six branches. The origin of these arteries is very various; they are usually derived from the aorta, and separated, at their origin, by a larger or smaller interval; the lowest may arise quite near the bifurcation of the aorta, and the highest just below the cœliac axis. In some rare instances the renal artery has been described as arising from the common iliac, internal iliac, and middle sacral. The right and left renal arteries have been found coming from a common trunk, they may arise from the anterior or lateral part of the aorta. The suprarenal frequently gives off an upper renal, and it less frequently is derived from the upper lumbar, hepatic, and right colic.

FIG. 282.—Large Median Artery (*M*), taking the Place of the Radial in the Formation of the Superficial Arch and giving off Outer Digitals. (Reeves.)

The branches of the renal artery, instead of entering the hilum, may penetrate the kidney at its upper or lower end. It is not uncommon to see the normal artery entering the hilum, and two or three supernumerary branches piercing the upper and lower end of the gland. In two subjects I found the kidney was supplied by two arteries arising from the aorta at some distance apart, one going to the extreme upper end, and the other to the extreme lower end of the kidney; no artery entered the hilum (Fig. 283). The vein and duct were normal. This variation I once met with while performing nephrectomy on the dead body. R. Quain met with a case of absence of the renal artery on one side. Multiple renal arteries occur normally in fishes, lizards, snakes, crocodiles, and birds, and in man are due to a persistent early fœtal condition.

SPERMATIC ARTERY.—Sometimes double, not infrequently derived from the renal. Three spermatic arteries have been seen.

COMMON ILIAC ARTERIES.—The place of origin of these arteries depends on the place of division of the abdominal

aorta. This may be as high as the upper border of the third, or as low as the lower border of the fifth lumbar vertebra. In three out of four cases the aorta divides opposite the lower border of the fourth lumbar.

The common iliac arteries vary considerably in length. I once saw them only 1.8 cm. (three-fourths inch) long in a negress, and, in another case, 2.5 cm. (one inch). In the large majority of cases, according to R. Quain, the length varies from 3.7 cm. (one and a half inch) to 7.5 cm. (three inches). The greatest length is about 10 cm. (four and a half inches).

The right and left common iliacs differ in length very often, the right, owing to the aorta dividing to the left side of the spinal column, is often the longer, but the left may be the larger, and in about one-third of the cases they are of equal length (R. Quain).

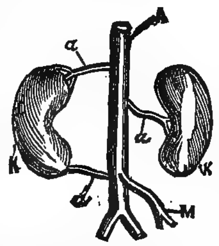

Fig. 283.—Abnormal Right Renal Arteries. An artery distributed to each extremity of the kidney, but none entering the hilum.

When the left is longer than, or equal to the right, it is owing to the left artery descending to a lower level than the right. The artery has been seen dividing into internal and external iliacs as low down as the iliac fossa.

The common iliac on one side has been reported absent by Cruveilhier and Walsham. In this case the aorta divided into three branches, two on the right (external and internal iliac), as is seen in birds, and one on the left (common iliac). Surgically, these variations are of great interest.

Internal Iliac.—The place of division of this vessel varies considerably; it may divide as low as the margin of the sacro-sciatic foramen and as high as the upper margin of the sacrum. The point of division is of importance surgically; when the trunk is short it is more deeply placed in the back part of the pelvis, but when it is of some length, then a part of the artery is likely to lie above the pelvic cavity, and therefore would be much more easily reached by the surgeon (R. Quain). It has been found as short as 1.2 cm. (half an inch), and as long as 8.2 cm. (three and a half inches).

The branches are given off from this artery very variously. In many cases there is no division into anterior and posterior trunks. The artery occasionally gives off one, and sometimes two branches before it divides. The variations of most of the branches of this artery, being of no surgical importance, will not be discussed here.

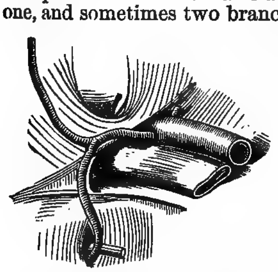
Fig. 284.—Obturator given off from the Internal Epigastric, and passing to the Inside of the Crural Ring to reach the Obturator Foramen. (After Gray.)

Obturator.—According to R. Quain, the obturator artery arises from the epigastric in one case in three and a-half. His conclusions are derived from observations in 361 cases. I have observed 500 cases (250 subjects), and have found this abnormal arrangement much less frequently than Quain. I have found the obturator coming from the epigastric in only one case in nine (55 in 500). Quain found the obturator derived from the external iliac in 6 cases out of 361. I found it only 3 times in 500 cases. Quain found the epigastric giving off the obturator 23 times on both sides. I found this arrangement 11 times.

When the obturator arises from the epigastric or external iliac, it reaches the thyroid foramen by arching either to the inner or outer side of the femoral ring. If it arches to the inner side of the femoral ring, along the edge of Gimbernat's ligament, then, in case of strangulated hernia requiring operation, it would be in great danger of being wounded (Fig. 284); in fact, this accident has happened more than once.

In nine only, out of the fifty-eight cases in which the obturator proceeded from the epigastric and external iliac, did I see the artery going to the inner side of the femoral ring. In the remaining forty-nine cases it either crossed it, in a few cases, or held a position well to the outer side in the majority (Fig. 285), so that in only about one case in fifty is there danger of wounding the obturator in the operation for strangulated hernia. The explanation of the origin of the obturator from the epigastric is simple enough. Normally we have the pubic branch of the obturator anastomosing with the pubic branch of the epigastric; these vessels become enlarged, and the proper obturator branch of the internal iliac either remains undeveloped or becomes obliterated.

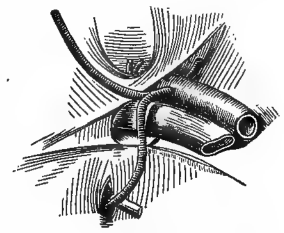
Fig. 285.—The Same, passing to the Outside of the Ring. (After Gray.)

In four cases I have seen the obturator, epigastric, and internal circumflex arise together from the external iliac, and once these same arteries were seen to arise by a common trunk from the common femoral two centimetres below Poupart's ligament. In one case the epigastric and obturator arose together from the femoral, a little below Poupart's ligament. In some cases, in which the obturator arises from the epigastric, there is a small branch, representing the obturator, derived from the internal iliac.

Internal Pudic Artery.—This vessel is occasionally of small size, and fails to supply all the usual branches; in such an event these are given off from an accessory pudic. The branches furnished by the accessory artery are usually those branches going to the cavernous body and dorsum of the penis, the pudic itself ending as the artery of the bulb. In a few instances the pudic ends as the superficial perineal, the other branches coming from the accessory vessel.

The accessory pudic is, as a rule, given off from the deep pudic within the pelvis; it then passes alongside the bladder and prostate, and, after piercing the triangular ligament, supplies the dorsum of the penis and the cavernous body, and, perhaps, the bulb. It may be given off from the obturator in the pelvis, or from the epigastric.

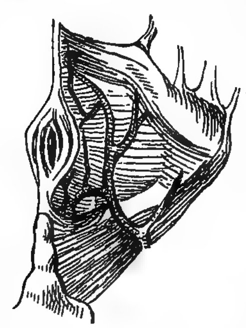
Fig. 286.—Abnormal Internal Pudic Artery, which has a course midway between the ischial tuberosity and the coccyx. (After Henle.)

The pudic artery has been seen passing up to the perineum midway between the tuberosity of the ischium and the coccyx, and ending as the superficial perineal and artery of the bulb (Fig. 286).

Artery of the Bulb.—Is sometimes of large size, placed further back than usual, and ascends obliquely to the bulb; in such a case it would necessarily be wounded in the operation of lithotomy. It may arise from the accessory pudic; when this happens it would be placed well in front of the usual incision for lithotomy.

The *dorsal artery of the penis* has in some cases been seen to arise from the obturator artery near the thyroid foramen, from the external pudic of the femoral, and from the deep femoral. In the first case it would be in danger of being wounded in lithotomy. The two arteries of the penis sometimes unite to form a single trunk, or are united by transverse branches. Mr. Spence has described a large prostatic artery which gained the perineal surface of the prostate without dividing into minute branches. Wounds of the prostatic arteries have led to fatal hæmorrhage in cases of lateral lithotomy.

The *sciatic artery* is sometimes replaced by a branch from the gluteal. In a few cases this artery has been seen

Arteries.

of large size, taking the place of the femoral (see under Variations of Femoral). There is sometimes a large comes nervi ischiatici artery. The gluteal artery has been reported as absent (Roberts), its place being taken by a large branch from the femoral, passing outward and backward to the gluteal region.

External Iliac Arteries.—The length of these arteries varies according to the point at which the common iliacs bifurcate; they usually measure 7.50 cm. (three inches) to 10 cm. (four inches) in length. In those rare cases where the main artery of the limb is a continuation of the sciatic, it is much reduced in size.

Epigastric Artery.—May arise at a higher point than usual. R. Quain reports it in one case 6.4 cm. (two and a half inches) above Poupart's ligament. It arises from the femoral in about one case in twenty. The usual place of origin is close to or opposite Poupart's ligament. It may, in rare cases, arise from the deep femoral.

The origin of the obturator from the epigastric has already been noticed. In a few cases the epigastric has been seen coming from the obturator when that vessel is a branch of the internal iliac.

I have, in four instances, seen the epigastric arise in common with the internal circumflex artery of the deep femoral. In three of the cases the common stem arose from the femoral 2 cm. below Poupart's ligament; in

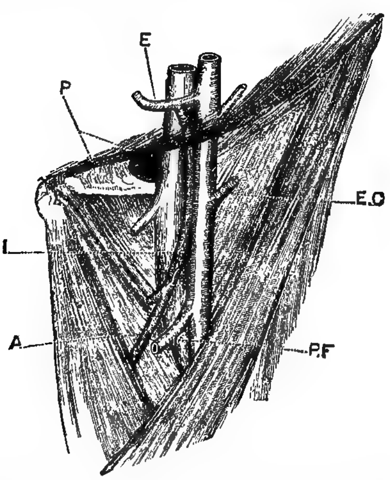

Fig. 287.—Abnormal Origin of the Internal Circumflex Artery (I); E, epigastric artery; PF, profunda femoris.

the fourth, 2 cm. above the ligament. In the last-named case the internal circumflex passed beneath Poupart's ligament in the same compartment of the femoral sheath as the artery, and continued down the thigh about 5 cm., lying between the artery and vein; it ended, after giving off a large branch to the adductor muscles, as the internal circumflex proper (Fig. 287). A similar anomaly has been observed by Mr. A. Thompson (*Journal Anat. and Phys.*, April, 1883), but in the cases described by him the artery passed internal to the femoral vein, and would, he thinks, have been wounded in the operation for relieving strangulated femoral hernia. A similar arrangement of vessels exists normally in the American black bear. I have met with three cases in which the obturator, epigastric, and internal circumflex arose by a common stem, two below Poupart's ligament and one above.

Circumflex Iliac Artery.—The origin of this artery is sometimes from the femoral. It is occasionally double.

Femoral Artery.—The femoral artery has, in some rare cases, been found of small size, and terminating near the knee-joint. When such a condition exists, the main artery of the limb is furnished by a branch from the internal iliac, generally the sciatic (Fig. 288), which is much enlarged, and accompanies the sciatic nerve to the popliteal space, whence the course of the artery is the same as if the distribution had been normal. This is the usual arrangement in birds.

Cases have been reported in which the femoral divided into two portions, which united below to form again a single vessel. Sir Charles Bell, when ligaturing the femoral for popliteal aneurism, met with this anomaly. Though the ligation of the femoral did not arrest the pulsation in the aneurism, the cause was not recognized till after the death of the patient, when it was found that the femoral was double, and only one of its divisions had been ligatured (*London Med. and Phys. Jour.*, vol. lvi., 1826). (See Fig. 289.) Tiedemann, Houston, Dubreuil, Tyrrell, and Quain also report cases. Mr. H. A. Kelly (*American Journal of the Medical Sciences*, January, 1882) reports three cases (one of which is doubtful), met with in the dissecting-rooms in Philadelphia. In two of these cases the artery divided below the profunda, and reunited just above the opening in the adductor magnus. The division has been seen above the origin of the profunda.

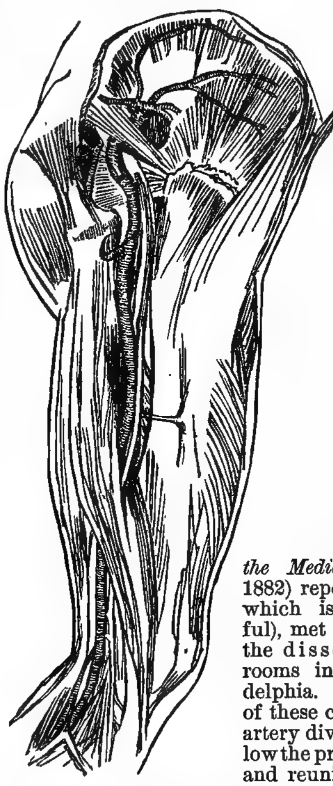

Fig. 288.—Posterior View of the Right Thigh. The ischiatic artery much enlarged, accompanying the sciatic nerve, and taking the place of the femoral artery. (After Dubreuil.)

The two femorals, when this arrangement occurs, run down the thigh, side by side, in separate fibrous sheaths, so that in cutting down on one the other would not be seen.

I have occasionally seen, in cases of high origin of the profunda, the latter artery quite as large as the superficial femoral, and running down the thigh parallel to it, beyond the apex of Scarpa's triangle. In such a case it would be difficult, in the living, to distinguish between the vessels, should ligature of the femoral be necessary. As a rule, the profunda lies to the outer side. The appearance of the above-described condition in Scarpa's triangle is very similar to those cases figured as double femoral, and I imagine that the cases of double femoral reported as seen in amputating the thigh, are only cases of large profunda arteries—especially as the disposition of the vessels below the amputated point is not described.

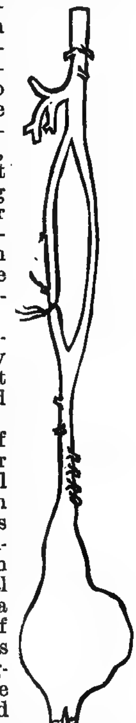

Fig. 289.—Bell's Case of Double Femoral Artery. Showing ligature of one of the trunks and the aneurismal tumor below. (After Bell, from *London Medical Gazette*.)

The *profunda*, or deep femoral artery, may be given off from the inner side of the main trunk, or even in some cases from the back part of the vessel. It may arise above Poupart's ligament, or as much as 10 cm. (four inches) below it. It not uncommonly arises 1.2 cm. (half an inch) below the ligament. When it is given off low down, one or

both circumflex arteries arise from the femoral. The deep femoral has been occasionally altogether wanting, its branches arising separately from the main artery.

The *external circumflex artery* not infrequently arises directly from the common femoral. It may be represented by two branches, and even three, which arise from the femoral or profunda—I have seen it arise in common with the internal circumflex. The *internal circumflex artery* also frequently arises directly from the femoral. It occasionally arises in common with the deep epigastric, and passes down to the thigh in the same sheath as the femoral vessel. This variety I have described under the Epigastric. It may arise with the epigastric from the femoral artery before the profunda is given off, and in some cases might be injured in the operation for strangulated femoral hernia. I have twice seen it arise with the obturator and epigastric from a common stem.

Unusual branches are, in rare cases, given off from the femoral. I once saw the dorsal artery of the penis given off from the common femoral, cross the thigh at right angles, and reach the dorsum of the penis by piercing the deeper scrotal tissue.

A large saphenous artery has been found which accompanied the great saphenous vein. It may arise above or below the profunda, course down the thigh between the adductor magnus and internal vastus, and pierce the deep fascia of the thigh on the inner side of the knee-joint, where it reaches the internal saphenous vein and accompanies it to the internal malleolus. This arrangement is the normal one in the rabbit and in some other mammals.

I once saw this branch, after reaching the inner side of the knee, wind round to the front of the joint, below the patella, and divide into a cutaneous branch and a branch which pierced the ligamentum patellæ to supply the interior of the joint.

Popliteal Artery.—This artery is not subject to many variations. The chief deviation from the normal disposition consists in a high division of its terminal branches. I saw this only twice in 250 subjects; in both, the artery divided immediately above the upper edge of the posterior ligament of the knee-joint. In 227 subjects Quain found a high division in 10. Portal reports a case of low division of the popliteal, the artery dividing about the middle of the leg into anterior and posterior tibial. In some cases of high division, the peroneal artery arises from the anterior tibial; this was the arrangement in one of my cases. The artery and vein, usually so constant in their relation, may, in rare cases, change places. When there is a third head to the gastrocnemius muscle it usually passes between the artery and the vein.

Cases are reported (Otto) of branches from the popliteal proceeding upward along the semi-membranosus muscle, and ending in one of the perforating arteries of the profunda. Also an aberrant artery is described as being given off above the knee-joint, and joining the popliteal before its division (Hyrtl). A small saphenous artery has been seen which accompanies the short saphenous vein behind the external malleolus and anastomoses with one of the tarsal branches (Hyrtl). The azygos artery may be given off from one of the articular arteries. I once saw a common trunk give off the two superior articular arteries and the azygos. One or other of the articular branches may be absent, their place being supplied by an enlargement of the remaining arteries.

Posterior Tibial.—In cases of high division of the popliteal the tibial is larger than usual. It may be increased or diminished in size. When increased, it partly takes the place of the peroneal or anterior tibial, and, when diminished, it may be reinforced by transverse branches from the peroneal near the ankle. The posterior tibial may be of very small size and end near the middle of the leg, its place being taken by a large peroneal artery which furnishes the plantar arteries. In a lesser degree of diminution of the posterior tibial, the anterior tibial, or rather its dorsalis pedis branch, furnishes the arteries which form the plantar arch and its branches. In these cases the external plantar artery ends near the accessorius muscle. I have several times seen a muscular slip, arising from the lower end of the fibula, or more commonly from the tibia, cross the tibial vessels behind the internal malleolus. The nerve is occasionally placed to the inner side of the artery, at the lower part of the leg.

Peroneal Artery.—This artery, as described above, may take the place of the posterior tibial, or it may be of small size, and its place be supplied by a branch of the posterior tibial. The anterior peroneal branch may be of large size, and take the place of the lower part of the anterior tibial, furnishing the arteries supplying the dorsum of the foot.

In cases of high division of the popliteal, the peroneal artery generally arises from the anterior tibial. It also arises in the same way, occasionally, when no high division takes place. I have seen it furnish a large internal calcanean branch as well as an external. An accessory peroneal sometimes exists.

The *internal plantar artery* is sometimes of very small size, ending in the flexor brevis pollicis muscle, or it may be of large size, and furnish digital branches to the great and second toe.

The *external plantar* is occasionally very small, ending in the accessorius muscle; when such a condition exists the dorsalis pedis artery furnishes the deep plantar arch and digital branches. I have several times seen this anomaly. The artery is occasionally of large size, and partly takes the place of the dorsalis pedis branch of the anterior tibial. The digital arteries of two toes, generally the second and third, not infrequently come from a common stem. The deep arch is, in rare cases, double.

Anterior Tibial Artery.—In some cases this artery is given off from the posterior tibial in the middle of the leg. When there is a high division of the popliteal it may give off the peroneal, and may pass beneath the popliteus muscle. In the leg it may be subcutaneous, its pulsations being easily felt under the skin. Velpeau reports a case in which this artery did not pierce the interosseous membrane, but passed to the front of the leg round the fibula with the musculo-cutaneous nerve. It may be altogether wanting, its place being supplied by perforating branches from the posterior tibial, or it may end in the muscles about the middle of the leg. When there is such a distribution the deficiency is made up by an enlarged anterior peroneal or plantar artery. It not infrequently fails to furnish digital branches, which, in this event, come from the plantar arteries. The artery may be of larger size than usual, and take the place of the peroneal artery in some cases, and the plantar branches of the posterior tibial in others; the dorsalis pedis branch being of very large size, as mentioned in the description of the varieties of the posterior tibial. The dorsalis pedis artery sometimes ends in the neighborhood of the cuneiform bone. The anterior tibial, in some rare cases, gives off an anterior tibial recurrent to the knee-joint.

Francis J. Shepherd.

ARTERIES, COMPRESSION OF.—Compression of arteries may be performed either by the finger, by means of a tourniquet, by a graduated compress and bandage, by a ligature tied tightly around the limb, or by a pad placed in the flexure of a joint, such as the axilla, elbow, or knee.

The circumstances under which an artery requires compression are frequently of such a nature that means for the compression have to be extemporized; an efficient tourniquet can always be contrived with the aid of a handkerchief, strings, a strip of the clothing, and a small hard object as a stone, potato, or even a mass of earth; the stone, or whatever is at hand, is folded into the handkerchief or cloth and is placed directly over the vessel to be compressed, and the handkerchief, cloth, or string is made to tightly encircle the limb; this can be made more effective by twisting the ends of the cloth with a key, umbrella, or stick.

Severe hæmorrhage, however, from an artery always demands quick and efficient digital compression. In some instances the bleeding vessels may be compressed in the wound, when the compression is made to check hæmorrhage from a divided artery; but ordinarily the ves-

sel must be compressed on the proximal side of the wound. (The subjects of Compression in Aneurism and Compression during Amputations, will be discussed under those headings.)

The *arteries of the scalp* (the supra-orbital, the anterior branch of the temporal, the occipital, and the posterior auricular) may all be effectually compressed against the bones over which they lie by means of digital pressure. The *temporal* artery may be compressed digitally at a point between the root of the zygoma and the auricle, against the bone on which it lies, viz., the root of the zygoma.

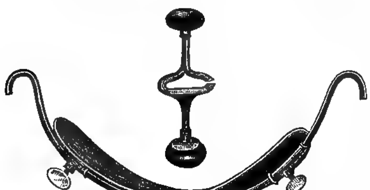

FIG. 290.—Esmarch's Elastic Compressorium.

The *facial* artery may be compressed by the fingers as it passes over the body of the lower jaw; the coronary arteries may be compressed by grasping the lips between the thumb and finger.

The *common carotid* artery may be compressed digitally in the omo-hyoid triangle between the sterno-mastoid muscle and the hyoid cartilage, against the bodies of the cervical vertebræ.

The *subclavian* artery may usually be compressed digitally in the supra-clavicular fossa, the pressure being made against the first rib over which the artery passes. This is a somewhat difficult procedure, especially in stout subjects, but it is frequently necessary in some cases of injury to the axilla, in amputation at the shoulder-joint, and in aneurism.

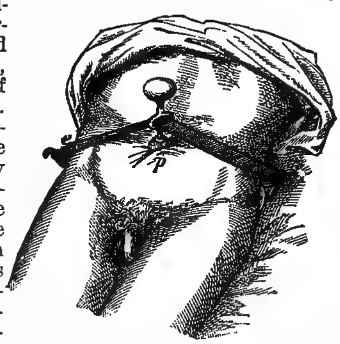

FIG. 291.—The same instrument in position.

The *axillary* artery may be compressed digitally when the arm is raised to a right angle with the body; the pressure should be made along the inner border of the coraco-brachialis muscle (Holden's "Landmarks").

The *brachial* artery may be compressed, either by the tourniquet or digitally, at almost any point in its course, but best where it lies on the tendon of the coraco-brachialis, at the middle of the arm. The pressure must be made outward and backward directly over the vessel, as it lies internal to the biceps muscle, and against the humerus. It is commonly made at this point to check hæmorrhage from wounds of the arm, forearm, and hand, and during operations on the forearm or at the elbow-joint. Efficient pressure may be made on the brachial artery as it divides into the radial and ulnar arteries in the space in front of the elbow, by placing a pad of paper, lint, or cloth, or a small round object in the bend of the elbow, and causing the patient to firmly flex the forearm upon the arm. This would be, however, but a temporary means of compression. (The brachial artery may be compressed in the upper part of its course by placing a hard body in the axilla and binding the arm firmly to the side.)

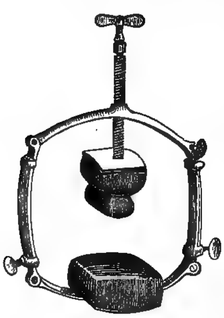

FIG. 292.—Skey's Arterial Compressor.

The *radial* and *ulnar* arteries may be compressed at the wrist by the fingers, by pressure applied around the limb, or by a graduated pad placed over each artery, and a splint and roller bandage applied from the hand to the elbow. Compression of these arteries may also be effected at almost any point in the forearm by simply tying a strip of bandage or other material tightly around the limb.

The *abdominal aorta* may be compressed by the fingers or by the abdominal tourniquet at the umbilicus and against the lumbar vertebræ. The most common conditions necessitating this compression are abdominal aneurisms and post-partum hæmorrhages. Successful results have been obtained in cases of abdominal aneurism by compressing the aorta, the pressure in some cases being kept up for many hours, and the patient generally being under the influence of an anæsthetic. In this class of cases pressure is best made by an abdominal tourniquet. In post-partum hæmorrhage the bleeding may be controlled usually by compression of the abdominal aorta with the fingers. One case has been reported in which such compression was successfully made by passing the hand into the fundus of the uterus and compressing the aorta against the vertebral column (*Gazette Médicale*).

FIG. 293.

The *common iliac* artery may be compressed by the hand in the rectum.

Compression of the *femoral* artery is very frequently required in wounds and operations of the lower extremity. Very efficient pressure may be made on this vessel just below Poupart's ligament, in Scarpa's triangle; digital compression, the tourniquet, and the various apparatus, as weights, shot-bags, etc., which are used to check or diminish the force of the circulation in this vessel, are best applied here. The direction of the pressure should be backward and upward against the pubes; the pad of the tourniquet, when that instrument is used, should be placed in the apex of Scarpa's triangle. In emergencies, an improvised tourniquet may be applied on the inner aspect of the middle third of the thigh, the pad, or whatever takes the place of the pad, being placed over the sartorius muscle. "In making digital pressure in Scarpa's triangle, it is easy, generally, to control the vessel by slight pressure with the thumb, provided the fingers have a firm hold on the great trochanter" (Gross).

FIG. 294.

The *popliteal* artery may be compressed by the graduated compress, tourniquet, or fingers in the popliteal space; the pressure should be directed against the femur and nearer the inner than the outer border of the space. Hæmorrhage occurring below the knee may sometimes be controlled by placing a compact pad in the popliteal space and strongly flexing the leg on the thigh.

The *anterior tibial* artery may be compressed as it crosses the anterior surface of the tibia at the ankle, where its pulsations may be felt.

The *posterior tibial* artery may be compressed by the fingers as it passes behind the internal malleolus. Its

pulsations are distinctly felt at this point. The compression would always have to be digital, as it would not be practicable to apply a tourniquet of any kind here.

The *dorsalis pedis* artery may be compressed over the instep, as it lies along the outer border of the extensor longus pollicis muscle, either digitally or with a pad and bandage.

In the two latter instances compression would only be made in cases of wounds about the foot.

The vessels of the limbs may be partially compressed and the blood-pressure reduced by what is known as "forced flexion." In the upper extremity, this is accomplished by forcibly flexing the hand in the prone position at the wrist-joint and flexing the forearm on the arm. In the lower extremity, the leg is flexed on the thigh and the thigh on the pelvis. Hæmorrhage from wounds of the extremities may be more or less completely checked by this method.

Hæmorrhage from wounds of the limbs may be checked by applying Esmarch's elastic bandage from the extremity of the limb to a point above the wound, and then tying a section of rubber tubing tightly around the limb, after which the elastic bandage may be removed.

William H. Murray.

ARTERIES, HEALING OF, AFTER LIGATURE, ACUPRESSURE, AND TORSION. Although the introduction of the ligature is commonly ascribed to Paré, there is sufficient evidence to show that it was employed by surgeons in the earliest historic times. No mention is made of the ligature by Hippocrates, but the ancients not only used styptics and the actual cautery, but also ligature and torsion. It is highly probable that the Alexandrians were familiar with the use of the ligature three centuries before the Christian era, for Celsus (born 30 B.C.) speaks of it as a well-known fact and recommends its use. Rufus of Ephesus, a century later, makes the following mention of torsion: "Vas immissa volsella extendemus et moderate circumflectemus: at ubi ne sic quidem cessaverit [hæmorrhagia] vinculo constringemus." Archigenes and Galen both mention tying vessels for the purpose of stopping hæmorrhage; the name of Antyllus also bears testimony to the skill of Roman surgeons, and in the Museum at Naples there may be seen a forceps, with sliding attachment, evidently intended to use with the ligature. We find the ligature of arteries mentioned again in the seventh century by Paulus of Ægina, whose teachings were still preserved by the Italians in the sixteenth century.[1] In Lanfranchi's "Surgery" (1295) occurs the following passage: "Oportet te nunc aut venam ligare et ipsam de loco extrahere, et caput venæ vel arteriæ contorquere, aut ferro candente sanguinem sistere."

It is uncertain, however, whether ligatures were employed on large vessels before Paré's time. To this great surgeon is due the credit, not only of fully appreciating the value of this mode of hæmostasis, but of making it a universally applicable method. At this period, the middle of the sixteenth century, the imperfect knowledge of the anatomy and physiology of the circulation prevented a due appreciation of the advantages of the ligature, and even Guillemeau, who was the champion of his friend and teacher, confined the use of the ligature to primary amputations. Although Wiseman in England, Fabricius Hildanus in Germany, Fallopio, and others favored the ligature, these were but isolated examples, and at the opening of the eighteenth century the actual cautery was still the customary method of arresting hæmorrhage at the Hotel-Dieu.

The contrast between the two methods at that time was not indeed as great as it would seem to-day. A glance at Paré's plates shows the forceps as an instrument of rude pattern and clumsy make; no attempt was made to isolate the vessel; veins, nerves, and arteries being included in one knot. No wonder that surgeons had a "horrid apprehension of compressing the nerves," and that Petit,[2] with whom modern investigation on the healing of arteries may be said to have begun, actually proposed compression as a substitute for the ligature. It was he who first called attention to the agency of the thrombus in checking bleeding, the blood around the end of the vessel being termed the *couvercle*, and that found within the lumen the *bouchon*. The retraction and contraction of the vessel were soon recognized by Morand, who also called attention to the rupture of the inner walls by the ligature. Pouteau, of Lyons, thought that the swelling of the tissues surrounding the mouth of the vessel was as important a factor as any other in bringing about the arrest of hæmorrhage, and he devised what has since been called the mediate ligature. This was, however, a return to obsolete methods, and a protest was soon raised against its brutality. In England, Gooch and Kirkland[3] dwelt strongly upon the action of the vessel-wall, and the former showed that the sides even became adherent for some distance, the vessel shrinking into a cord. White even thought that the clot was injurious and should be removed; John Bell, on the other hand, thought that the extravasated blood in the tissues compressed the vessel, which subsequently receded by adhesive inflammation. Hunter gave a great impetus to the study of the process of repair in arteries, through his views on healing by first intention. He first enunciated a theory, which has since led to much discussion, concerning the organization of the thrombus and its vascularization, which he likened to the changes seen in the embryo of the chick; but he also believed in a direct adhesion of the arterial walls. It was due to him, also, that the subsequent establishment of a collateral circulation was recognized. To Jones,[4] however, has been pretty generally accorded the credit of producing the classical work upon this subject. By a large and varied series of experiments on animals he was able to give a complete account of the macroscopical appearances showing injuries to arteries, which, in the main, holds good to-day. He found that when a large artery was divided it retracted into its sheath, and contracted slightly at its extremity, a coagulum forming within the sheath and external to the vessel, and appearing like a continuation of the artery; and that, later, a slender and conical coagulum formed within the vessel, being only partially adherent to its walls. Permanent occlusion, he says, is effected by the inflammation of the wall, the vasa vasorum pouring out lymph which, according to the theory of that day, became organized, that is, was endowed with an independent power of forming tissue. As the external clot was absorbed it was replaced by this coagulated lymph, the vessel in the meantime contracting up to the first branch, a delicate ligament being eventually all that remained. In partial division of the vessel, this writer tells us, a coagulum forms between the vessel and its sheath at the point of injury, and the wound in the wall is closed with coagulated lymph, which subsequently forms outside as well. Wounds less than one-fourth the circumference of the vessel in animals are capable of healing so as to occasion little or no obstruction in the canal, and rarely do such injuries lead to aneurism—a curious fact noticed by all subsequent experimenters. If the artery be surrounded by a tight ligature the middle and internal coats will be completely divided as if by a knife, the external coat remaining entire, upon the strength of which coat very much depends. He speaks of the "ulceration of the ligature," which expression at the present time, when both ends of the knot are cut short and it is allowed to heal in, conveys a false impression of the nature of the subsequent changes. The process of repair is essentially the same as that already described. He was inclined to attach too little importance to the thrombus, or internal coagulum, as he called it; and in ordinary accidents he thought it contributed nothing to the suppression of hæmorrhage. Jones's views were generally accepted, but, since he differed essentially from Hunter respecting the rôle played by the internal thrombus, this question now became the chief subject of discussion, one party maintaining that the thrombus was organized and formed the cicatricial tissue; the other believing that this function was performed by the walls of the vessel, which were supposed to be united by an adhesive inflammation. In France the majority favored Hunter's views, though Andral believed with Cruveilhier in the correctness of the latter theory, as did also Guthrie in England. In

Germany opinions were about equally divided until Stilling, by an elaborate series of researches, the most extensive since those of Jones, seems to have definitely settled the question that the thrombus did become organized. Guthrie also established the fact that a longitudinal slit in human arteries of medium size, as the temporal, may heal without obliteration of the vessel, and that in vessels of considerable size hæmorrhage may be arrested without aid, the power and influence of the heart over the circulation through the arteries being greatly over-rated; a fact also observed by Velpeau.

With the rise and progress of histological research the question of the organization of the thrombus was subjected to new tests. Schwann, in 1838, had developed his "cell theory," that it was only through the intervention of cells that further development could take place, and not, as Henle still maintained, through an amorphous blastema formed from coagulated lymph, which could be directly changed into new tissue. It was now through the lymph that the organization of the thrombus was supposed to be effected, and Zwicky, a pupil of Henle, who first investigated with high power, describes minutely the absorption of the red corpuscles and the gradual metamorphosis of the homogeneous structureless cytoblastema into organized tissue.

Rokitansky[5] called attention to the changes taking place in vessels which had been excluded from the circulation owing to a change in the current of the blood, as the umbilical arteries and the *ductus Botalli*, and he pointed out that the process was the same in ligatured vessels. It was not, in the opinion of this writer, through the intervention of a thrombus, but through a collapse in the walls and their subsequent fusion by the deposition of a new layer, that obliteration took place. The labors of Porta[6] contributed much about this time to our knowledge of the development of the collateral circulation. Virchow,[7] who was at first more or less influenced by the views of Hunter, as he became convinced of the power of cell-action and inaugurated the theory of "*omnis cellula e cellula*," discarded the views of Schwann and Henle, and saw in the white corpuscles of the thrombus the organizing elements. Although he conceded that the vessels in the thrombus might be developed from the vasa vasorum, still he did not think that the presence of the cellular elements of the new tissue could be explained by a primary growth inward of the cells from the vessel-wall. Both he and Rokitansky recognized that the spaces filled with fresh blood were not new-formed vessels, but channels hollowed out by the blood-current which are to be distinguished carefully from the vascularization of the thrombus. This process was termed by Virchow the "sinus-like degeneration;" the term "cavernous metamorphosis" has also since been applied to it by Rindfleisch. The latter likened the thrombus to a tissue, of which the white corpuscles were the cells and the red corpuscles and fibrin were the matrix; and the gradual series of changes of the white corpuscles into connective-tissue cells were described both by him and O. Weber, who also thought that new blood-vessels were formed by them which subsequently united with the vasa vasorum. It was by these observers that the theory of the organization of the thrombus received its fullest elaboration.

Attention had, however, already been called, both in France and Germany, to the action of the lining membrane of the vessel, and the views of the above-mentioned writers were farther strengthened by an important communication from His,[8] who showed that the endothelium was of an essentially different origin from the epithelium of the skin and mucous membranes, and belonged rather to the group of connective substances. (The term *endothelium* is used for the first time in the writings of this author.)

Waldeyer[9] thereupon concluded that the endothelium was capable of producing a young connective tissue within the vessel, which tissue was subsequently vascularized by vessels springing from the vasa vasorum, and that the thrombus was absorbed as this tissue grew into it. The same thing, he thought, occurred in the blood-clot in extravasation, the process of organization always taking place at the edges only. A series of observations to the same effect were made by Thiersch[10] on the corpus luteum.

The investigations of Recklinghausen on the wandering cells, and of Cohnheim[11] on the passage of the white corpuscles through the walls of blood-vessels, turned the discussion into a new channel. The theory of the organization of the thrombus was now virtually abandoned, and the dispute, as to the origin of the cells found in the thrombus, now lay between those who derived such cells from the endothelium and those who assumed that they had wandered in through the walls of the vessels. The views of the latter were strengthened by the experiments of Bubnoff,[12] who, after applying ligatures to veins, rubbed vermilion granules on the outside of the ligatured vessels. These granules were afterward discovered in cells found within the thrombus, and he concluded as follows: "that the white corpuscles of the thrombus lose their power of wandering and take no part in the cell-formation of the organizing tissue. Cells take part in the organization of the thrombus which creep in large numbers into the vein. The mass of the cells are probably derived from the layers of the vessel walls and from the surrounding tissues." Billroth adopted this view, but still maintained that the white corpuscles of the thrombus did take part in the process.

While the views of Cohnheim, as to the origin of the new cells in inflamed tissues, were adopted by a large number of pathologists, there were still many who believed that the pre-existing cells of a part were capable of proliferation. The most prominent exponent of the latter school was Stricker, who believed not only in a subdivision of the cells, but of the intercellular substance also, and in the conversion of the latter into an amœboid material.[13] Were the views of the former school correct, endothelium could undergo no proliferation; if, on the other hand, the old view of cell multiplication still held good, there was no need to fall back upon the emigrant cells with which to people the thrombus.

Bubnoff's experiments were explained by Thiersch, who assumed that the granules were not carried in by the cells, but that they floated in the plasmatic current which flowed through the intercellular spaces of a network which formed around wounded vessels, and were thus carried into the interior of the latter. Baumgarten[14] also showed that, after a certain period, granulation tissue forced its way through the various ruptures near the ligature, and carried with it the pigment granules.

A convenient mode of studying the endothelium was devised by placing a double ligature upon a vessel, first having gently pressed out the fluid blood between the two points. This was tried by Kocher, who found no change in the endothelium; but Durante showed that the isolation of a fragment of vessel in this way caused a necrosis, which accounted for the non-action of the endothelium. Raab[15] found that if the connection between the vessel and its sheath was not disturbed, the isolated portion could still be nourished by the vasa vasorum, and that proliferation of the endothelium could then be readily observed; and Baumgarten saw cell proliferation within such a section of artery, although it had been carefully isolated from its sheath—which proves, at least, that a considerable portion of a vessel can be excluded temporarily from the circulation by the ligature without sloughing, the vascular connection in thoroughly aseptic wounds, as in his experiments, being rapidly re-established. Raab went so far as to assert that "the growth of endothelium and granulations" (see Baumgarten, page 9) "are as easily demonstrated as any fact in pathological histology, but the question of the action of white corpuscles and wandering cells is founded on the doubtful basis of hypothesis." This challenge, as it were, was taken up by Senftleben,[16] who repeated Raab's experiments, and was unable to find any cell-growth except close to the ligature, where it might be accounted for by a growth, through the rupture in the wall, of cells coming from without; the same appearances being noted even in cases where alcohol had been previously injected into the segment to kill

the endothelium. Such segments were also removed and placed in the peritoneal cavity of rabbits, after having been first soaked for two days in alcohol. There action of the endothelium was out of the question; and yet the same growths that Raab and Baumgarten had seen were still found. Here then was a vindication of the activity of the wandering cells. Even the swollen endothelium, which Raab saw in cross-section of small vessels in inflamed parts, was declared by him to be composed of white corpuscles attached to the wall. He says, certainly with justice, that if such growths take place, we should have all small vessels in an inflamed part completely obliterated.

Experiments by Lee, Beale,[17] and Schultz,[18] concerning the repair which follows a small injury to the wall of a vessel, together with Zahn's account of the formation of a "white thrombus," all show that the wound is filled by a clump of white corpuscles, which afterward lose their contours and become fused into a more or less homogeneous or striated mass. The breaking down of these corpuscles, according to Zahn, sets free fibrin ferment and paraglobulin to act upon the fibrinogen contained in the plasma, and coagulation consequently takes place. Beale and Lee inferred, and Schultz thought to show by observations made at a later stage, that the subsequent closure of the wound was effected solely by the further deposit of white corpuscles from the blood, the endothelium taking no part in the process. Pfitzer,[19] however, repeated Schultz's experiments; and, while admitting the formation of the white thrombus in the way indicated, he showed that repair really took place by the formation of a granulation tissue on the outside and by a corresponding growth of the endothelium on the inside. Zahn[20] also observed a similar growth of endothelium in vessels whose inner walls had been ruptured by a ligature temporarily placed upon the vessel, allowing the circulation to re-establish itself immediately.

The study of endarteritis appears to have convinced most observers that the growths which eventually obliterate the smaller vessels arise from the internal tunic. A growth of mucus-like tissue is sometimes seen under the endothelium; at other times its upper layer also appears to be involved; and, if coagulation of the blood occurs, the cells may grow into the clot so formed. According to Cornil and Ranvier, a further growth of such tissue in larger vessels will lead to a breaking down of the media, and to a growth of cells outward into the adventitia. A number of observers have found a new formation of vessels in the obliterated artery produced by the force of the blood-current forming a channel.[21] Around such spaces may be seen newly-formed elastic laminæ, constituting a newly-developed wall for the new vessel, which thus does the work of a collateral branch. Analogy would suggest a growth also of the internal tunic in vessels after ligature, and Cornil and Ranvier, indeed, consider the two processes identical.

The weight of opinion latterly has been decidedly in favor of the activity of the inner tunic of the vessel in the healing process after ligature. Such is the view of those who have studied the subject in this country during recent years. Shakespeare[22] derives the new formation from the endothelium and subjacent cells of the intima. A collection of these cells is to be found at the point of ligature by the end of the first twenty-four hours, forming a cushion upon which the clot is seen to be resting. To this new growth Shakespeare gives the name "plastic clot." The thrombus, or "fibrinous clot," takes no part in the process, but is pushed up by the plastic clot, in which latter signs of vascularization begin to show themselves as early as the sixth day, communication being effected with the vasa vasorum between the fifteenth and thirtieth day. A growth similar to that just described may be produced by pressing together, with forceps, the inner walls of the vessel just above the ligature, in applying what the author styles the "modified ligature." He has been able to observe the activity of the endothelium actually under the microscope, a cell being detached and floated off as a white corpuscle, thus confirming Klein's views on the origin of white corpuscles.

Senn[23] finds that the cicatrix is the exclusive product of connective tissue and of endothelial proliferation, and that permanent obliteration takes place in an artery in from four to seven days. This would imply a reliance chiefly upon the intima for the production of the new tissue. Wyeth,[24] though he thinks that permanent closure is effected by cells of the intima, does not consider a division of the inner coats necessary. In his investigation of endarteritis he thinks that the connective tissue cells of the adventitia, the white corpuscles, and the endothelium, all respond to the inflammatory action.

Thoma has recently elaborated the views of Rokitansky on the analogy with the closure of the umbilical arteries and the *ductus Botalli*; and he has described the formation of a hyaline and fibrillated connective tissue in the deeper layers of the intima, as a compensatory endarteritis occurring at birth in that part of the arterial system specially concerned in the fœtal circulation, in the arterioles of the kidneys in chronic nephritis, and in the stumps of arteries after ligature. The closure of an artery, he says, whether physiologically, or as the result of an operation, depends upon the slowing of the current. It begins with a contraction of the media; if this contraction be enough to restore the normal rapidity of the circulation, further changes are confined to an atrophy of the muscular wall sufficient to correspond with the diminished calibre and diminished tension. If this change does not suffice, it is supplemented by a compensatory thickening of the intima. The observations of Schultz respecting the shape of the cicatrix in an arterial stump, on its elongation or thickening upon one side of the vessel according to the proximity of a branch, are in this way explained.

The appearance of the thrombus has been carefully studied by Shakespeare, who finds that it forms gradually and that it presents a stratified aspect, looking like a column of red blood-corpuscles surrounded by fibrin and white corpuscles, which lies coiled up in the vessel. The tendency of a slowly-moving blood column to retain a shape impressed upon it, can be demonstrated under the microscope in the tongue of a frog. The blood is deposited in this way in successive layers or coils. The apex is composed of a homogeneous clot containing some large ovoid cells. As to its size, Raab says the old view that a thrombus must reach as far as the first collateral branch, is exploded, both by experiments on animals and observation on man.

As to the cause of its formation, Cohnheim takes the ground that it is due to an injury to the endothelium; the old view that it might be produced merely by a slowing of the current not holding good, for even in marasmic thrombi we find slight injuries to the internal membrane; moreover, a ligature may be put around the vessel without producing coagulation, provided the endothelium be not injured. Wyeth, however, who, in ligaturing an artery, prefers to avoid a rupture of the inner coats, does not confirm this view.[25] Kocher also says that the clefts in the walls are not of themselves sufficient to check the blood-current; for, if the ligature is immediately removed, the circulation is restored. Baumgarten thought to avoid formation of a thrombus by keeping the wound aseptic, but we find no other such observations recorded.

The shape of the thrombus is usually represented as ovoid, the apex, which is unattached, being directed toward the lumen of the vessel; the proximal thrombus is usually longer and always broader than the distal thrombus. Bryant explains the ampulla-like dilatation of the proximal end by the more rapid coagulation of blood here, which coagulation is attributed by Lister and Callendar to the greater turmoil into which the blood is thrown on the cardiac side by impinging against the obstruction, the churning process leading to the deposit of fibrin more or less pure; but they also agree that the deposit of blood-clot is favored by slowness of movement, as on the distal side in the lower extremity when the anastomosis is not free. Were such conditions as these the controlling element, one would expect to find the proximal thrombus "white" (see Zahn above) and the distal thrombus "red."

It will be observed that those histologists who have interested themselves in the repair of arteries have considered the question usually from some special standpoint, such as the "organization of the thrombus," the rôle of the white corpuscles, of the wandering cells, or of the endothelium. We shall now undertake to follow the various pathological changes which occur, in and around the vessel, from the time the ligature has been applied until the process of cicatrization has been fully completed.[26] These changes may be compared not inaptly to those which occur in long bones after fracture. In both we find an external and an internal callus, in both there is a growth of tissue which has only a provisional existence, and in both the dense walls subsequently undergo certain changes which enable them to take a tardy but important part in the final cicatrization. In arteries, however, the external callus produces a ligamentous union only between the two fragments.

When a large artery is tied in its continuity, the intima and a variable portion of the media are usually ruptured, and the adventitia is gathered into a dense tendinous sheath around the constricted ends. The first noticeable change is the formation of the thrombi, which are usually developed within the first twenty-four hours, and the accumulation of a granulation-like mass of cells about the ligature, which, if it has been cut short, is completely enveloped by them. This growth appears to proceed

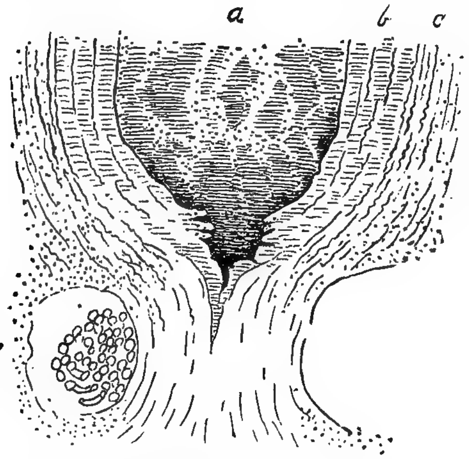

FIG. 295.—*a*, thrombus; *b*, media; *c*, adventitia; *l*, ligature.

from the periadventitial tissue, and varies according to the amount of injury done by the ligature to the vessel walls, or to the irritation which it produces. If the coats of the vessel have been unnecessarily bruised and a certain amount of extravasation has taken place in consequence, or if the ligature itself, for some cause, has created irritation, the surrounding inflammatory tissue will form a well-marked callus. If an excessive irritation has been produced, the growth of this protective tissue may be retarded, or it may be destroyed and the danger of hæmorrhage correspondingly increased. Following the development of this external growth, we find that it extends some distance up and down the sides of the vessel in the periadventitial tissue, the round cells of which it is composed invading only the superficial layers of the adventitia: the breadth of the growth is, of course, greatest at the point of ligature; in length it reaches usually to a point on a level with the ends of the two thrombi; when fully developed it is consequently spindle-shaped (Fig. 296). At the point of ligature, where the fibres of the outer wall are densely packed (Fig. 295), the wandering cells do not penetrate during the first few days; but just above and below the ligature they may be found already invading the media as early as the second day; occasionally the apex of a pyramidal-shaped mass of such cells will have reached the thrombus. These cells appear to exert a solvent action on the bunch of fibres projecting from the ring of the ligature, which thus becomes gradually liberated from all connection with the vessel, the two ends of which now retract and leave the knot imbedded in the centre of the callus. The fibres of the ligature itself soon become infiltrated with cells, and by the tenth day they may have already disappeared, or, if its resisting powers are greater, may remain encysted for some time. The period which the ligature requires for this separation varies greatly according to the size of the vessel and character of the ligature, and is longer in man than in animals. If the artery has been properly dissected out, this external growth will be observed forming a callus-like ring, in which the two ends of the vessel are imbedded, in size about twice the thickness of the vessel, and it can still be seen well developed at the end of two months (Fig. 296). In the specimen from which the accompanying drawing was taken the ligature had caused suppuration about it, and had formed a fistulous track at the fundus of which some fibres were found still remaining. By the end of three months the external callus has disappeared, and only a slender cord unites the peripheral to the proximal end.

Already by the fourth day changes are noticed within the vessel. Observing the proximal thrombus we find an increase in the number of white corpuscles, particularly near the point of ligature, not in an isolated mass, but mingled with red corpuscles. Masses of coagulated fibrin with young cells (white corpuscles of clot, wandering cells from arterial coats, and rarely also periarterial tissues) are attached to the frayed ends of the media which have been cut by the ligature, and are more or less inverted. The endothelial cells, when not firmly compressed by the thrombus, as in the distal end, are in a state of activity, undergoing proliferation to a moderate extent. Occasionally, loop-like masses of cells may be seen projecting into the clot, or a delicate anastomosing network of stellate or spindle-shaped cells; but the total amount of this cell-growth is small as compared with the size of the thrombus.[27] In the meantime, in the second week, masses of granulation cells are seen infiltrating that part of the wall which is separating or has already separated from the ligature.

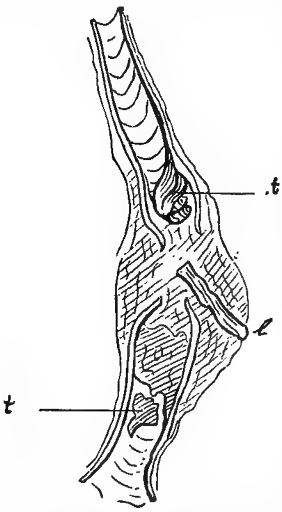

FIG. 296.—Artery two Months after Ligature, showing External Callus. *l*, sinus at site of ligature; *t*, remains of thrombus.

Even at this period, with the external growth carefully dissected away, as is the custom in museum specimens, the vessel appears to have united by first intention, that is, by a direct union of the media and intima side to side. But the infiltration and softening continues until the walls are separated and expand, like the petals of a rose, yielding before the advancing growth of granulation tissue. The deeper portions of the clot are now infiltrated with two growths; the more superficial (that is the portion nearest the open lumen of the vessel) is composed of tissue grown from the intima and media and wandering cells, and the deeper is composed of vascular granulation tissue which has pushed its way in from without. Viewed at the third week, the ends of the vessel will be found expanded and the space between them filled with well-formed granulations, such as are seen on the surface of a healthy wound. A portion of the thrombus, sometimes a large portion, has not been infiltrated, but is attached firmly to the top. A longitudinal section of such a specimen gives a striking illustration of what is understood as "healing by scabbing." As the clot shrinks the spaces left between the

Arteries.

granulations, which have now rolled over one another in cloud-like masses, become continuous with the open lumen of the vessel, and the so-called "canalization" of the thrombus is thus effected. An injection mass can be forced from the vessel for some distance into these spaces, but as yet they do not communicate with the vessels of the granulation tissue. This communication, usually, does not occur until the second month, that is, until the provisional growth has reached its period of highest development. The vessel walls have in the meantime been undergoing certain changes. A proliferation of the cells of the intima, as has been noticed by so many observers, unquestionably takes place; but the amount developed is not sufficient to supply more than a very small part of the provisional tissue. The cells, however, have begun to grow before the other tissue has made its way into the vessel, and at this period serve the purpose of attaching the thrombus to the walls of the vessel, but even in this work they are aided by other cells from the media. They also furnish a new endothelial covering to the permanent cicatrix, and a lining to the new vascular spaces that have been formed. When the elastic lamina has been ruptured (and this is frequently seen on the sides of the vessel near the ligature, and also here and there higher up as far as the thrombus extends), we find an intimate connection at such points of the media with new growing tissue within the vessel. In the second week, cells may be seen springing from the media and growing into either the clot or a clump of cells attached to the inner wall. The cells are round and spindle-shaped, frequently in bundles. Evidences of cell activity in the media are abundant, and in some specimens in animals a proliferation of the muscular cells through the whole thickness of the media is observed, giving a considerable increase to the width of this layer. The elastic lamina is frayed out at its divided end, and glistening elastic fibres are seen extending downward into the ex-

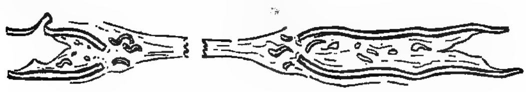

FIG. 297.—Human Carotid Artery Four Years after Ligature, showing nearly complete obliteration from aorta to bifurcation.

ternal growth as the two ends of the vessels gradually retract from one another. At the end of three months the provisional tissue has been absorbed, and we find the walls united by a permanent cicatrix which joins the sides of the vessel, still somewhat separated from one another. It consists, in medium-sized arteries, of a crescent-shaped mass of tissue, the concavity presenting to the lumen, the horns running up on either side of the vessel. One horn may be long and the other short, the crescent being placed somewhat excentrically. The longer horn may be sometimes thickened (see Schultz and Thoma), as in Fig. 297, if a branch lies opposite to it. In the largest vessels the cicatricial tissue occupies a considerable portion of the calibre of the vessel.

On the surface of the cicatrix is seen a thin layer of endothelium; beneath this, in medium-sized vessels, there can be seen a layer of delicate tapering spindle cells with staff-shaped nuclei, forming a continuous layer from one horn to the other. They run parallel to one another and to the arc of the circle made by the crescent, and resemble in all respects muscular cells; in short, a genuine muscular layer is found here. Beneath this layer is a mass of cicatricial connective tissue which plugs the space lying directly between the ends of the retracted walls. (Fig. 298.) The cicatrix is pierced by a vessel of considerable size which rapidly tapers to a point and anastomoses with a capillary network, ramifying both in the cicatrix itself and in the ligamentous band outside. This central vessel, which in larger cicatrices becomes tortuous and gives to the cicatricial tissue a "cavernous" appearance, may be regarded as the unobliterated residuum of the lumen. In such a specimen as Fig. 297 represents, the crescent-shaped muscle is not apparent as a separate layer, but its equivalent may be traced with the microscope as bearing a similar relation to the vascular spaces surrounded by the cicatrix. The minute vessels of the cicatrix resemble in all respects those usually found in cicatricial tissue.

We find in this anatomical peculiarity of the cicatrix an explanation of its immunity from aneurismal dilatation. The protective influence of the thrombus enables the process of cicatrization to complete itself before the cicatrix is called upon to withstand blood-pressure, and it is then armed with a muscular coat, (as is the normal vessel wall), which acts not unlike a levator ani muscle in sustaining and modulating the force of the blood-column.

The ligament which unites the two ends of the vessel represents, in part, the residue of the external callus; it has become much elongated by the retraction of the two ends. During the healing process, a small portion of the vessel walls have become disintegrated by the new growth, and a portion has atrophied and has been absorbed, the remaining walls have shrunk greatly, by retraction, and their calibre has been filled to a greater or less extent by a cicatricial tissue; so that the vessel has become practically obliterated up to the first branches of the collateral circulation.

When a double ligature is placed upon a vessel, and the intervening portion allowed to remain intact, it is grad

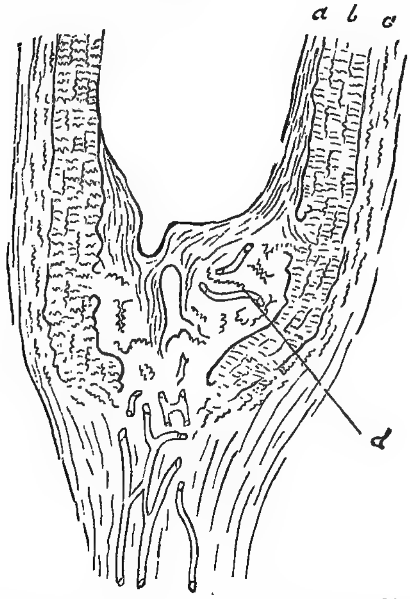

FIG. 298.—Femoral Artery of a Dog Three Months after Ligature. *a*, new muscular layer; *b*, media; *c*, adventitia; *d*, cicatricial connective tissue.

ually absorbed by the process above described, granulation tissue growing in at both ends as the fragment is separated from the ligature, and finally infiltrating the whole mass. It may be possible at the beginning of this process (*i.e.* during the first forty-eight hours), to demonstrate the passage of a few wandering cells through some injured spot, or to verify the proliferation of certain endothelial cells within the segment; but they, like the other elements of this isolated mass, have no further function to perform, and are eventually destroyed.

The thrombus is a mere passive structure, and takes no part in the growth, but is protective and affords an excellent medium for the germination of the new tissue. Its upper portion is not penetrated by the new growth, but rests upon it and forms a sort of protecting scab. It is deposited gradually, and has a stratified appearance. Its size appears to be dependent upon the amount of injury done to the vessel and the resulting inflammation. If the intima or the elastic lamina have been ruptured in handling the vessel, as can frequently be demonstrated by the microscope, some distance from the point of ligature, clots will form at these points, and the thrombus thus be-

come elongated. Occasionally the apex is formed of white corpuscles only, and may be free or lightly attached to the wall by a cell-growth from the intima. The distal thrombus is shorter than the proximal, and much narrower, so that there is but little difficulty in distinguishing them from one another.

It was, at one time, the custom to place a double ligature upon large vessels, in place of a single ligature, and to divide the vessel between them. This procedure was advocated by Jones, who says: "In the single ligature, although the knot is soon covered up and protected by an effusion of lymph, it is placed in the centre of a portion detached from the surrounding cellular membrane, and the process of repair cannot go on so well, as the nutritive vessels are cut off. In the double ligature, the knots are placed where the connection of the vessel with the surrounding tissues is complete."

This theory has recently been revived by Walsham, who considers the separation of the artery from its sheath as important a factor in influencing the result as tightness of the ligature or division of the coats, inasmuch as the vitality of the artery depends in a great measure, he thinks, upon the blood-supply received from the sheath. But Holmes objects to this method on account of the free dissection and exposure of adjacent vessels rendered necessary: if the knot "will keep its hold on the vessel until the seat of the ligature is buried in a mass of new fibroid material, secondary hæmorrhage, if not impossible, is, at least, very improbable." The method, he says, has passed out of use when secondary hæmorrhage was common, to be brought back when it is rare.

The supposed danger to the vessel wall, incurred in applying the single ligature, is based upon anatomical rather than upon pathological conditions, and, in the light of present knowledge, is a theoretical rather than a practical objection.

Ligatures.—It was chiefly due to Jones's investigations that the modern single thread found, at one time, almost universal adoption. Cutting short both ends of the knot was adopted as long ago as 1798 by an American naval surgeon. The disadvantages of a silk or hempen ligature were supposed to be due to its non-absorption and the liability to produce suppuration. An illustrative case is quoted by Lister.[28] Six hempen ligatures were placed upon the thyroid vessels in an operation for goitre, and, although perfect asepsis had been preserved, they all came away at the end of one to eight months, having caused the formation of a slight amount of pus about the knots. The interstices of the threads were loaded with a form of micrococcus, occurring in groups of two or three instead of chains, to which Lister has given the name "granuligera," a form of microbe frequently found in wounds that are perfectly aseptic, producing an acid fermentation in the serum which thus becomes a source of irritation.

The ordinary silk or hempen ligature, if cut short, may be absorbed; if a coarse thread is used, the knot will form a foreign body of considerable size, which will be more likely to produce local suppuration than if the thread be a fine one, in which latter case, in wounds treated antiseptically, absorption may reasonably be expected. When it is necessary to apply a "mediate" ligature, as on the pedicle in ovariotomy, the greater holding power of hemp renders it superior to the animal ligature, and the testimony of ovariotomists as to their influence upon the healing process is not unfavorable.

The introduction of the animal ligature is generally ascribed to Physick, whose ligatures were made of chamois leather rolled on a slab, to render them hard and round. Sir Astley Cooper tried them, and they were used in this country on all the large vessels by Jamieson, of Washington, who advised using the buckskin soft and a little broader than the ordinary thickness of the skin. With the introduction of antiseptic surgery animal ligatures have largely superseded other means of securing vessels.

The most common form is the catgut ligature. It is prepared from the small intestine of the sheep by scraping away the muscular and mucous coats, all that remains being the submucous cellular coat and a narrow strip of peritoneum. The translucent membranous tube which remains can be twisted, entire, for the coarser forms of catgut, and is then dried. For the finer kinds, the submucous coat is split by means of razor blades, more or less numerous, according to the degree of splitting required, connected with a conical piece of wood which is pushed along the tube. The "chromicized gut" is prepared by dissolving one part of chromic acid in four thousand of distilled water, adding to the solution two hundred parts of pure carbolic acid—in other words, a one to twenty solution of carbolic acid in an exceedingly dilute solution of chromic acid. The solution should be used immediately, and an amount of the gut equal in weight to the carbolic acid should be placed in it, and allowed to remain forty-eight hours. The catgut is then taken out of the solution and dried; when dry it is placed in a one to five solution of carbolic oil, and is then fit for use. If it has not been properly prepared, the substance of the catgut becomes converted in the course of a very few days into a soft, pultaceous mass, which, when we examine it by a microscope, we find to consist of remains of the old cellular tissue of the submucous coat, the interstices among the fibres being filled with cells of new formation. The catgut tissue is infiltrated with young growing cells, and it is obvious it is this infiltration which is the cause of the softening; but, on the other hand, if the catgut is properly prepared, instead of being infiltrated by the cells of new formation it is only superficially eroded. Until nearly a fortnight has elapsed, erosion does not begin. It then proceeds gradually, and, therefore, the thicker the catgut the longer is the time required for its complete removal. We may fairly consider that from a fortnight to three weeks is long enough for the persistence of a ligature upon an artery in its continuity. If over-prepared—that is, rendered too hard by the chromic acid—it may be discharged whole, as in the case of the hempen ligature quoted.[29] Many of the failures with catgut can be referred to improper modes of preparation; and, although the danger of obtaining a material that is too readily dissolved is not so great since the introduction of the chromicized gut, the necessity of being so dependent upon the care of the manufacturer constitutes a certain objection to its use.

Other forms of ligature, recently introduced, are those prepared from the kangaroo and whale tendons.

Barwell[30] has proposed, in the treatment of aneurism, the use of the ox-aorta ligature, which can be applied so as not to divide the internal coats, and need not ulcerate through the artery. He thinks it becomes organized, having seen remains inseparably mixed with the surrounding tissues fifteen months after it had been applied. In other cases it is absorbed. It is prepared by cutting spiral strips from the aorta. A weight is attached to the end of each flat band thus produced, and the band is hung up and dried. Just before use it may be moistened in a solution of carbolic acid.

Dent[31] reports a case of the application of the tendon ligature to the carotid and subclavian arteries followed by death at the end of ten days. In an examination of the carotid, the knot of the ligature was found in close contact with the artery, encysted in a small cavity in the effused lymph. The knot was almost gelatinous in appearance. Transverse sections showed that the external coat of the artery "was not ulcerated," and this condition is considered due to the slight swelling and softening which such a ligature undergoes. New blood-vessels were found developed in those parts of the tendon which lie close to the artery, that is, rows of spindle-shaped cells, with spaces between, were seen branching in the tendon tissue, and blood-vessels were seen passing into both the artery and tendon; the tendon was also infiltrated in other portions with granulation cells; some of the adjacent muscular coat was being attacked and eaten away. This question of the organization of the ligature was first raised by Lister, who now explains that he does not mean that the catgut comes to life again, but "new tissue forms at the expense of the old, that the old tissue is absorbed by the new, and that as the old is absorbed new is

put down in its place." Evidently he is here describing the formation of the provisional tissue, or external callus, and the gradual absorption of the ligature. The observations of Dent may be interpreted in the same sense, the granulation tissue pushing its way into the interstices of the knot preparatory to "eating it away," as it already has done portions of the muscular coat. In Barwell's case the preservation of a distinct band, fifteen months after ligature, may be accounted for by supposing that the ligature had not been wholly absorbed. Much misconception has arisen from an improper preparation of such specimens. In order properly to appreciate existing conditions, the vessel should be removed with the surrounding inflammatory tissue attached to it, should then be placed in some hardening fluid for a few days, and, finally, a longitudinal section, with a sharp razor, should divide it into equal halves (Fig. 296).

Metallic ligatures have not been favorably received, though satisfactory results have been reported, a number of such ligatures not interfering with union by first intention. The difficulty of regulating the tension of the ligature, and the amount of consequent injury to the vessel, appear to be the chief objections to them for ligature in the continuity. To smaller vessels they are not so easily applied as are pliable ligatures.

Torsion was not unknown to the ancients, as has already been shown, and was employed by certain surgeons in the middle ages; but in more modern times, surgeons were not familiar with it until it was brought to the notice of French surgeons by certain statements of a visitor from Germany. Both Velpeau [32] and Amussat apparently claimed the credit of introducing it, the former, in consequence of his experience, when a student with a veterinary surgeon, in the twisting of the pedicle in spaying and castration, and both, as the result of their observations on the immunity from hæmorrhage in lacerated arteries. The method employed by Velpeau is thus described: "After having seized the vessel by its extremity, I separate it from the surrounding tissue, and grasp it, at its deepest point in the wound, with another forceps, to hold it firmly while it is turned on its axis, three to eight times, by the first pair of forceps." He appears to have employed the method in several amputations. Its supposed advantage was the avoidance of a foreign body in the wound. He recognized the fact that animal ligatures would be equally good for this purpose, and also the disadvantage of torsion in diseased vessels, and that small vessels were not easily isolated. It was, perhaps, for these reasons, that, although tried thoroughly by some of the leading surgeons in France and Germany, it fell into disuse until revived by Bryant,[33] in England. The effect of torsion, according to the latter, is a twisting of the elastic fibres of the adventitia above the end of the vessel, and a retraction and incurvation of the middle and inner coats; the twist in the outer coat is permanent and cannot be unfolded by any legitimate force; the middle and inner coats are retracted in the direction opposed to the blood stream, approximated and overlapped. They sometimes assume a nipple-shaped projection, at others, a valvular form, being not unlike the semilunar valves of the heart, and closing as perfectly; in some cases, again, they appear to split; in all, the coagulation of the blood is favored. The safety from hæmorrhage, according to Bryant, rests upon the twist of the external, the retraction of the internal coats, and the coagulation down to the first branch, while, in acupressure, the permanent safety depends upon the last alone, temporary protection being afforded by the needle.

Kocher found numerous and irregular lacerations of the inner coats, over a considerable distance of the wall, and independent of one another, while, in ligature, the ruptures were circular and only close to the point of ligation. In unlimited torsion there is considerable narrowing of the lumen. Owing to these peculiarities, it has the advantage of favoring a rapid coagulation.

The effect of the limiting forceps in bruising the inner wall of the vessel, and thus favoring both coagulation and repair at the bruised spot, is noticed by Shakespeare, who recommends a similar bruising in ligature (the "modified ligature"). The process of healing is, according to the latter observer, the same, in its essentials, as that which occurs after ligature.

Acupressure.—The introduction of this method of hæmostasis is to be accredited to Sir James Simpson [34] (unless an obscure passage in John de Vigo's writings be interpreted otherwise than as a description of the ordinary ligature). He saw, in the ligature, a foreign body in the wound which cut through the two coats at the time of its application, and ate through the outer coat by a process of ulceration, mortification, and gangrene. Variations in the shape or material of the ligature did not overcome these disadvantages. It was for this reason, principally, that amputation stumps healed with so much greater difficulty than wounds in the operation for vesicovaginal fistula, although the latter were constantly bathed in leucorrhœal discharges and urine. The application of the ligature isolated a portion of the end of the vessel, which remained in the wound as a piece of dead flesh until it came away with the ligature. The needle, on the other hand, did no injury to the vessel and caused no irritation, its use being based upon "the great pathological law of the tolerance of living tissues for the contact of metallic bodies embedded in their substance." Bryant showed, however, that the ligatured portion did not slough, but became adherent and vascularized.[35] Even though the vitality of such a fragment be completely destroyed, it need not become a slough unless another element, that of decomposition, be introduced, and may, therefore, be surrounded by healthy granulating tissue and become disintegrated and absorbed by a process already described.

Although English surgeons supposed that no injury was done to the vessel by the needle, Hewsen [36] expressly states that no laceration of the internal coat takes place, and Shakespeare does not mention any alteration of the tunics, Kocher and other German writers have demonstrated longitudinal slits in the intima, but not so extensive as those occurring in torsion. The vessel is thrown into longitudinal folds, which become sufficiently firmly glued together to retain this shape long enough, after the removal of the needle, for the thrombus to form and become firmly attached to the walls. A specimen examined by Kocher at the end of twenty-two hours showed no thrombus, the walls being compressed and somewhat thickened, but a fine probe could be introduced between them. At thirty-six hours a well-formed egg-shaped thrombus is represented by Shakespeare. A drawing by Kocher shows a specimen fourteen days old, when the walls have already separated from one another, and the thrombus is short and wide, having a concave surface presenting toward the lumen, and a convex surface at the other end: the relation the thrombus bears to the vessel is that of a cork to a bottle, beyond the neck of which it does not project. It is probable that the apex had been detached. Hewsen also mentions that the thrombus is confined to the compressed spot. The final cicatrix has a shape similar to that described as following ligature, and is developed by a similar process of repair. In acutorsion, the lumen of the vessel is narrowed for some distance from its extremity.

In acupressure, in the continuity, the proximal and peripheral ends of the thrombus are continuous, as are also the walls of the vessel, which at first are thickened by a connective-tissue growth; the subsequent changes differ in no way from those already described.

Ogston has tested mechanically the comparative strength of arteries secured by ligature, acupressure, and torsion, by subjecting them to the pressure of a column of mercury. It was found that a column one hundred and fourteen inches in height was insufficient to rupture the ligatured artery. Twisted vessels unfolded at an average height of thirteen inches (or 6.5 pounds to the square inch pressure). Estimating the internal blood-pressure at from two to eight pounds to the square inch, he concludes that it would appear likely that vessels secured by torsion are very liable to secondary hæmorrhage, especially when the heart, recovering from the immediate shock of an operation, begins to beat more firmly. In acupressure, the column of mercury showed an average height of 23.5 inches. It would, therefore, seem a more reliable method, he says, than torsion, and less reliable than liga-

ture. According to Shakespeare, the healing process is slower, both in acupressure and torsion than in ligature.

A procedure somewhat similar to acupressure has been described by Pollock,[37] which consists in substituting a silver wire for the ligature, the ends being brought out through the skin covering the lips of the wound and twisted together. They are allowed to remain, on an average, five and a half days, with satisfactory results.

J. Collins Warren.

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36 Pennsylvania Hospital Reports, vol. i., 1868.

37 New York Medical Journal, 1869.

ARTERN. A saline spring in the vicinity of Merseburg, Prussian Saxony, situated at the confluence of the Unstrut and the Helme (Lat. 52° 7′ N., Long. 11° 58′ E.). Artern has been a resort for the invalids of Thuringia since early mediæval times. During the Thirty Years' War, the spring fell into disuse and its existence was finally forgotten. It was rediscovered in 1722, and its reputation, from that time onward, has been steadily increasing. The water of the single spring in Artern is a simple saline, used for bathing purposes, but not as a beverage. The method of its application is of the simplest kind. The bath is taken at a temperature varying from 36.5° to 39° C., with constant friction. The cases sent for treatment to Artern are the anæmic (although there is no iron in the water), and persons suffering from languid inflammation, from strumous, carcinomatous, and various dermatological affections, particularly old papular eczema and psoriasis. Like all saline waters, that of Artern promotes tissue metamorphosis, but it is extremely doubtful whether it has any effect on the resorption of neoplastic elements. The location of Artern is in the heart of the Thuringian mountains. Its climate is equable and mild, and its atmosphere is impregnated with saline and terebinthine vapors, thus rendering it a valuable resort for those to whom climate is of paramount importance in their retreat. The proportion of sodium chloride in the water is 2.4 per cent. There are barely traces of other constituents, and it is entirely neutral in reaction. The length of time requisite for the manifestation of therapeutic results is about six weeks. One of the most striking effects of Artern water is the vigor and elasticity which is produced in the bather after a very brief course of treatment.

H. F.

ARTHRITIS DEFORMANS. Arthritis deformans is a subacute form of inflammation of the joints, progressive in character, accompanied with but little fever, and distinguished from gout and rheumatism by the peculiar morbid changes it produces in the articular tissues, and by the absence of any known abnormal state of the blood. The name "rheumatic gout," which has been given to it, is evidently a misnomer, as it is neither gout nor rheumatism. Dr. A. B. Garrod calls it "rheumatoid arthritis," Cruveilhier, "usure des cartilages articulaires," Trousseau and other French writers, "rhumatisme noueux." Affections of the joints described as "arthritis sicca" and "malum coxæ senile" must be classed with arthritis deformans.

Description. — Arthritis deformans was not recognized as an affection *sui generis*, until modern pathologists succeeded in establishing the identity of the local morbid changes in the diseases described as rheumatic gout, arthritis nodosa, malum senile articulorum, etc.

The disease occurs either in the acute or in the chronic form, although the latter is much more frequent than the former; it also occurs at almost any age, and attacks both sexes, although women are more liable to the progressive polyarticular form than men, according to my experience.

The following typical case may serve as an illustration of the acute form.

A lady, aged forty-five, multipara, with no syphilitic or hereditary taint, married early in life, went on the stage, and, as an actress of some prominence, led an active and varied life, experienced many changes of fortune, travelled a good deal, never hesitated to expose herself to wind and weather, yet always enjoyed good health, until she was about forty-three. At this time she experienced a great deal of anxiety and depression of spirits by the loss of the last piece of property she owned, and was soon after taken with pain and swelling in both wrists and elbow-joints; the joints of hands, feet, and knees became affected soon after, and when I saw her, at the end of the first year of her affliction, there was scarcely a joint which did not crepitate on palpation, or at any attempt at passive motion, except those of the clavicles and mandibulæ. The knees and spinal vertebræ were in the worst condition, and hands and feet were crippled and distorted. She had some febrile disturbances during the first six months of the disease, and suffered much in consequence of pain and want of sleep. Her urine contained an excess of phosphates, no albumen or sugar.

The disease had, thus far, not been recognized, and various antirheumatic remedies had been tried in vain. The patient was now ordered small doses of propylamin before, and pil. ferr. sulph. and potass. carbon. after meals; good food and as much cod-liver oil as she could digest. Being a believer in the theory of a tropho-neurotic origin of many cases of arthritis deformans, and of this one in particular, I applied the galvanic current to the spine and upper cervical ganglia every alternate day.

By this combined mode of treatment, the disease became arrested and retrogressive within three months. The patient was then removed into the country, the same treatment was continued, and at the end of a year she had comparatively good use of her limbs, looked well and hearty, and was able to attend to her household duties. She has suffered no relapse during the past two years.

Such cases may, at first, closely resemble acute rheumatism, the more so, as slight elevation of temperature, rapid pulse, loss of appetite, and other evidences of constitutional disturbance are present; furthermore, several joints are attacked, the swelling is considerable, and there is distinct increase in the surface temperature of affected parts, with pain, tenderness, and redness. There are, however, wanting some of the characteristics of rheumatic fever—namely, the profuse sweating, endo- and peri-carditis, and the disposition of the inflammation to fly from joint to joint.

Of the more frequent chronic form, the following case will furnish a good example :

A woman, aged thirty-four, with no hereditary taint, as far as can be made out ; married twice ; two abortions, two births at full term. She nursed her last child, four years ago, for eight months, and suffered from galactorrhœa for some months after discontinuing lactation. This was accompanied by frequent headaches and the sensation of weakness, and a certain degree of general ill-health. Pretty soon she noticed painful swellings of some knuckles and of one wrist. By rest and proper hygiene and tonics these swellings subsided.

A few months later a relapse occurred, and both knees also became involved. At the same time several small, hard, movable nodules were observed in the subcutaneous tissue of her arms, while some of the joints crepitated on motion, and on digital pressure presented the feeling as if some gelatinous substance were present. During those attacks there was hardly any fever, but a variety of dyspeptic and neurasthenic symptoms were present. No perceptible effusion in the joints.

The patient has thus far—two years have elapsed—had at least half a dozen relapses, but they have been growing milder, and there is hope that the disease may be arrested.

SYMPTOMATOLOGY. — In the chronic (polyarticular) form, the first symptoms are generally pain in one or more joints, which come and go, either spontaneously or after exertion, combined with an unusually tired feeling about and in the same. The pains are neuralgic in character, fixed or diffused through the limb. In the course of time, a good deal of stiffness and discomfort is experienced, the joints enlarge and become unshapely by the proliferation of protuberances on the outer surface of the swollen epiphyses, and crepitation in moving or palpating the joints, is distinctly perceptible. There is generally but little effusion in the capsular ligament.

The adjacent soft parts, particularly the muscles, in a comparatively early stage of the disease, show a degree of atrophy, not at all commensurate with their inactivity alone ; it seems rather to be due to peculiar nutritive changes in the tissues themselves. I have observed, in some cases of arthritis deformans, small, hard, movable, and somewhat tender nodules in the subcutaneous and muscular tissues of the arm and elbow. I believe them to be mainly made up of connective-tissue. They certainly did not appear to me like "neurotic nodules," as Remak would have us believe, from his description of those which he had seen in arthritis deformans.

The disease has a decided tendency to affect the joints of the left and right sides symmetrically. This is often seen in the general progressive form, in which the disease appears to have a predilection for the distal joints, while in the rather stationary monarticular form, the malum coxæ senile, the advance, if any take place, is irregular. I have a case under observation in which the disease, after remaining fixed in one hip-joint for many years, leading to much distortion and shortening, at last attacked the fingers and toes.

The disease, if unchecked, travels over the whole body, affecting nearly all the articulations, and causing much deformity and distortion from the enlargement and contractions it produces. The (cervical) vertebræ may also become affected, in which event the patient may ultimately be rendered helpless for the remainder of his life. Fortunately the disease does not always proceed to this length, but is arrested at some stage or other of its progress, and then only a limited amount of distortion is induced.

The deformities produced by arthritis deformans are not altogether characteristic of this disease, for they are produced likewise by chronic gout ; but in their advanced conditions the separation of the one disease from the other is usually not difficult.

The changes in the limbs, when severely affected, are of the following kind : The hands are usually thin from the absorption of fat and wasting of the soft tissues, the extremities of the phalanges and heads of metacarpal bones being enlarged and nodular. The fingers are usually turned outward, and their joints are rigid, often flexed. As a rule, the metacarpo-phalangeal articulations of the fingers are flexed and the first phalangeal are extended, causing the second phalanx to be thrown backward ; the second phalangeal joint is also flexed. One or more, or all fingers in a hand may be thus altered. The phalangeal joint of the thumb is usually extended or bent backward. Sometimes the nodose condition is well marked, and, again, it is but slightly developed ; complete dislocation of some joints is occasionally met with. The wrists are stiff and enlarged, and admit of but little motion. The elbow is more or less flexed, and the joint enlarged, rounded, and misshapen from the alterations and hypertrophy of the heads of bones, cartilage, and soft tissues. The knees are generally flexed, much enlarged, and rounded from the same causes, and it is here where a limited amount of effusion often occurs, although it generally disappears again in the later stages. When the hip becomes affected, the thigh becomes flexed, with abduction or adduction of the lower extremity. As a rule, the hands become distorted and crippled at an earlier period than the feet. The jaw and the spinal vertebræ are frequently attacked, but they seldom become much distorted.

PATHOLOGY AND MORBID ANATOMY.—The blood has not often been analyzed in arthritis deformans. Garrod says he has failed to discover any pathognomonic changes, but it is a fact that uric acid has not been found, and thus we are able to distinguish the blood in this disease from that of true gout. The serum has the ordinary properties of that of healthy blood. The analysis of the urine has likewise given negative results.

Pathological anatomy has also enabled us to distinguish arthritis deformans from gout, on the one hand, by demonstrating the absence in the affected joints of deposits of urates of soda, which are constant in gout, and from rheumatism on the other, by showing the presence of ulceration of the cartilages, and of other structural alterations, which are not found in simple rheumatism, even after repeated attacks.

The morbid anatomy of this disease has been carefully studied by R. Volkmann and Adams. From the very commencement of the inflammatory action, the articular cartilage begins to suffer, and Volkmann is very probably correct when he recognizes the rapid proliferation of its elements, particularly on the free surface of the cartilage, as the essential factor of the disease. A slow process of absorption seems to take place, the cartilage splits up into fibres, vertical to the surface of the bone ; little depressions are observed, which at length coalesce, and the bone is left in part uncovered. As the disease proceeds the whole surface may be thus denuded, the osseous surfaces brought in contact with each other, and, in the movements of the articulations, they become polished in a remarkable degree by friction, and an ivory-like condition, termed eburnation, is produced.

More rarely, the spongy structure of the heads of bones is exposed by absorption of the denser matter of their extremities, and the ends of the bones become enlarged and misshapen by the formation of osseous protuberances.

Within the joints vegetations and bands are frequently seen, also foreign bodies of various size, some cartilaginous in structure, others having the consistence and texture of bone ; and these are usually adherent to the internal surface by ligamentous bands.

In the tissues surrounding the joints we notice frequent lesions of the tendons and their sheaths, and the muscles more or less atrophic and, in old cases, in a state of *fatty or connective-tissue degeneration.*

It is a much easier task to prove that arthritis deformans is neither gout nor rheumatism than to state what it is. A tropho-neurotic origin has been suggested by modern writers. Remak and Benedict were the first, I believe, who tried to connect diseases of the joints with irritative conditions of the spinal cord and the sympathetic. Later on Charcot and his pupils brought out the important fact that disease of the posterior columns of the cord frequently excites a morbid affection of one or more joints. True, the lesion in cases of tabes consists more often in a large effusion within the capsular ligament, but

in other cases structural changes are produced quite similar to those made by arthritis deformans.

Though we may be obliged to take into account traumatic agencies acting upon the joint of a limb already paretic, the frequent coincidence of joint-disease and lesion of nerve-centres is more than a mere coincidence, and deserves our attention.

Among the number of cases of arthritis deformans which I have seen in the course of the last twenty years, I have been forced to recognize the influence of general causes productive of irritation and exhaustion of nerve-centres, as much more potent in inducing an attack of the disease than the so-called rheumatic influences. Again, the symmetrical appearance and progress of the disease, in most cases, can be fairly explained by the supposition of causes located in the central nervous system.

The neuralgic symptoms and trophic changes around the joints, and finally the negative results following the antirheumatic mode of treatment in this disease, and, on the other hand, the positive results frequently obtained by proper hygiene, good food, tonics, cod-liver oil, etc., and the application of the galvanic current to the spine and sympathetic also support this view. Thus far, however, no autopsies have been made with reference to the condition of the cord in this disease, and we are only able to say this much with regard to it: it *usually occurs* in weakened subjects, and exposure to cold is in many cases the exciting cause of its development.

Etiology.—The disease is more frequent in women than in men, and is not often met with in early life, but many cases occur in women between twenty-five and forty-five years of age.

Hereditary disposition does not appear to exert any special influence, and is certainly much less powerful here than in gout. It is not uncommon to find one member of a large family suffering severely from the disease and the rest entirely free from it.

Individuals of weak frame are more liable to it than others, and it should be mentioned that patients having a phthisical diathesis are often the subjects of arthritis deformans. Everything which causes debility and loss of tone (in the circulation), such as poor food, hæmorrhages, frequent child-bearing, long-continued lactation, galactorrhœa, exhaustion by sexual over-indulgence and dissolute living, deep and prolonged grief, and severe and protracted mental anxiety, act as predisposing causes of the disease. In two instances I have seen it occur in the course of diabetes; Dr. Garrod has made a similar observation.

Cold is frequently an exciting cause of the disease, especially if it has been prolonged and has caused severe depression of the functions of the nervous system. In some cases injuries or shocks appear to have acted as exciting causes.

Diagnosis.—Garrod is right when he says: "Perhaps there is scarcely a subject of greater importance in the whole range of joint affections than the diagnosis of rheumatoid arthritis; for upon a correct understanding of it, depends the future comfort and physical well-being of a large class of persons." The affections with which it is apt to be confounded are gout and rheumatism. The nodes appear most to resemble gout; both of them are attended with pain and swelling, but in gout the integuments are generally inflamed, red, painful, and very tender, but they are never of bony hardness, like those of arthritis deformans. The gout attacks the patient in paroxysms of a few days, or weeks, and has complete intermissions, lasting at first for years, but afterward for shorter periods; it attacks men much more frequently than women. Arthritis deformans has no intermissions, and but slight remissions, for the nodes gradually enlarge, and the deformity and disorganization of the joint increase, impeding more and more the motion of the limb; the disease spreads to other joints, but does not leave those which had been previously attacked. Gout is generally inherited, while such is rarely the case in arthritis deformans; it is, however, generally preceded by a period of ill health, characterized by bad nutrition and exhaustion of the nervous system. Arthritis deformans generally begins as a subacute disease and the joint affection gradually increases; but occasionally it runs an acute course. When it does so, it is rapidly progressive, polyarticular, the large and small joints being equally attacked, and the great toes not being specially involved, as in gout.

From acute inflammatory rheumatism it is distinguished by the comparative freedom from constitutional disturbance, the longer duration of the paroxysms, and the absence of endo- and peri-carditis.

In chronic rheumatism we do not observe such structural alterations as in arthritis deformans. The most frequent difficulty which occurs is to separate chronic arthritis deformans from chronic gout. Careful search should be made in such cases for evidence of urate deposits on the ear and tips of fingers, and in the bursæ over the olecranon process of the elbow. An examination of the blood will eventually clear up the diagnosis; for in arthritis deformans there is no uric acid present.

Prognosis.—Arthritis deformans is a rather intractable disease; for its most common predisposing cause is a thoroughly impaired condition of the system, and this in many instances has arisen from influences which have been in operation for years. It is, therefore, not to be expected that an affection occurring under such circumstances can be rapidly cured; it is often a great achievement to arrest its further progress.

If the disease is far advanced and the joints are severely injured, it is impossible to restore the latter to their normal state, even if the constitutional tendency to the disease be arrested. When the disease is less advanced, and there is no insurmountable dyscrasia present that stands in the way of improvement of the general health; when few joints are affected and the progress of the disease has not been rapid, more or less complete recovery may be hoped for. When the affection is at its commencement, or at least no actual damage has been done to the bone and cartilage of the articulation, then a complete recovery will take place if the patient be properly treated.

Treatment.—From a consideration of the etiology and pathology of arthritis deformans the inference is but natural, that a supporting plan of treatment is what the patient stands most in need of, and that all debilitating measures must tend materially to increase the rapidity and severity of the disease. We must look to it that the patient have healthy surroundings, the necessary comforts and freedom from anxiety and care, good and nutritious food and plenty of it.

Gentle and general massage, applied by experienced hands, will improve the circulation, stimulate the nervous system, and thereby improve the patient's general nutrition, and help to arrest the tendency to further progress of the disease. For the same and other reasons, given above, I have applied the galvanic current to the spine and upper cervical ganglia in short daily or tri-weekly sittings, and have found it to improve the functional activity of the nervous system and the circulation by its stimulating effect upon the vasomotor nerves.

Frequent change of air and scenery should be advocated, and all prolonged mental exertion and physical fatigue should be avoided. A residence in a moderately warm climate during the winter months is desirable, but the air of the place should be dry and bracing.

Tepid baths are indicated, especially when the functions of the skin are defective, but baths are not curative in this disease, and care must be taken that debility is not induced by them.

As to medicines, colchicum is always worse than useless, neither are the alkalies of any value. However, if the first attack be ushered in by exposure to cold, I have been in the habit of prescribing: Propylamin, ʒ ss. to ʒ j.; aquæ, ℥ viij.; syrup. simpl., ℥ ss. M. A tablespoonful before each meal, to be continued for some days or weeks, as the symptoms of the case may indicate.

If anæmia exists, iron is called for. I give it in the form of pil. ferr. sulph., potass. carbon., āā gr. ij.—two or three such pills after meals; or as ferrum redactum with extr. cinchon. and rhubarb, or as ferr. albuminat. In more acute cases I found the syrup. ferr. iod., gtt. xx. to xxx., three times daily, more serviceable.

Cod-liver oil, the hypophosphites, and quinine, are particularly indicated when the disease has been attended with wasting of the body, or when the nervous system has been seriously implicated by depressing causes.

Arsenic has also been found useful in the latter variety of cases. I prefer the arsenious acid, gr. j.; piper, ʒ ss.; extr. gentian, q. s. f. pil. xxx.—a pill t. i. d. after meals. Cod-liver oil and iron may be administered at the same time.

The springs most adapted for the subjects of arthritis deformans are the chalybeate; the stronger saline and alkaline waters are apt to aggravate the disease. In some very chronic cases the natural warm springs have proved of much service.

As to local treatment, relief is frequently experienced, in the early stages of tenderness and swelling of the joint, from the application of blisters. Under this treatment the effusion will often quickly subside, and the tenderness will become much lessened, or even removed. Similar results I have had after the superficial but extensive application of the Paquelin cautery.

In the acute stage, the joint should be kept at complete rest; on the other hand, those articulations in which the disease has become chronic should be moved to such an extent as to stay the wasting of the muscles of the limb, and to prevent the stiffening of the joints.

Leonard Weber.

ARTHROLOGY. That part of anatomy which treats of the joints or connections between the denser parts of the skeleton. By means of these joints, or articulations, the skeleton, originally an apparatus for support, becomes an apparatus for locomotion. In its primitive condition the human skeleton is without joints, being represented, in the human fœtus before the fifteenth day, by a simple non-jointed rod of condensed embryonic tissue called the notochord, a form permanent in the lowest vertebrate (Amphioxus). This becomes ensheathed with tissue, which is the matrix of the more complex skeleton (Fig. 299). The substance of this sheath changes to cartilage at regular intervals, thus becoming segmented (Fig. 300).

Figs. 299 and 300.—Formation of Primitive Joints.

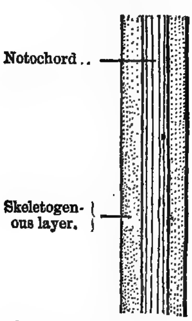


Fig. 299.—Notochord without Joints. (Fœtus fifteen days.)

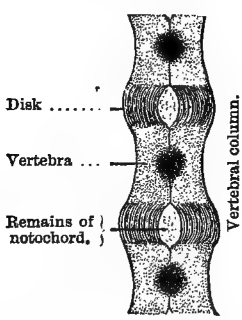


Fig. 300.—Joints derived from it. (Child at birth.)

Vestiges of the notochord are found in the adult as pulpy masses within the disks which unite the vertebræ. Elsewhere in the human body joints are formed in a similar way. Rods are laid down and then segmented by the differentiation of certain portions into cartilage, which may afterward ossify. The structures by which union is effected at the joints may, therefore, be considered as the altered remains of the original skeletal matrix. Around the segments this matrix remains as fibrous tissue, termed the perichondrium, becoming periosteum when ossification ensues, and between the segments it occurs as similar fibrous tissue, changing to fibro-cartilage in certain cases. When in the form of bands, straps, or membranous sheets, these transegmental structures are termed ligaments. They may unite not only the apposed ends of segments, but also the related sides. Sheets of this sort passing laterally from one bone to another in the same plane are known as interosseous membranes. Examples are seen between the radius and ulna, and between the tibia and fibula. The entire ligamentous system is closely connected with the fasciæ, of which it may be considered a specialization. (See Fascia.)

The prime characteristic of joints is, therefore, the movements which become possible by reason of segmentation. These movements vary according to the varying functions of the segmented members, and thus produce corresponding modifications of structure in the parts composing the joint. Upon these modifications the classification of joints depends. In all joints there is originally sufficient intersegmental tissue to permit slight and limited motion. Such are called primitive or amphiarthrodial joints. Examples occur in the adult between the bodies of the vertebræ (Fig. 300). In the course of development the osseous or cartilaginous tissue of the segments usually tends to encroach more and more upon the intersegmental structure. If no alteration occurs in this, the joint becomes less and less movable until complete fixation ensues. It is then termed synarthrodial or immovable. Examples are seen in the adult skull. The process may be carried so far as to wholly obliterate the joint. When the connecting substance is fibrous, the joint is termed a suture (Fig. 301); when cartilaginous, a synchondrosis (Fig. 302). Strictly speaking, the union of the shaft of a long bone with its epiphysis is a synchondrosis. There being no strain caused by movement in this class of joints, the periosteum passes over the intersegmental tissue without thickening into ligamentous structures.

Figs. 301 and 302.—Synarthrodial Joints.

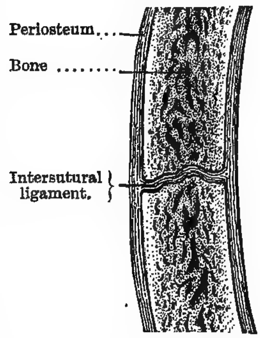


Fig. 301.—Suture.

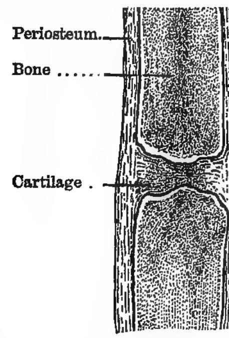


Fig. 302.—Synchondrosis.

In by far the greater number of cases the intersegmental tissue becomes altered. Between certain of the cells, vacuoles or small cavities form (probably by the enlargement of the lymph lacunæ of the connective-tissue), and these join together, making a larger cavity or cleft. The cells immediately around the cavity form a secreting surface, the synovial membrane, the product of secretion being a glairy fluid called synovia. The membrane resembles the similarly formed serous membranes of the body, as well in structure as in great vascularity, and in liability to sudden and dangerous inflammations. Synovial cavities are formed not only between the apposed segments of a joint (Fig. 303), but also where tendons rub over hard surfaces, or where the skin is closely applied to such surfaces and friction is frequent. (See Bursæ.) Small and imperfect synovial cavities exist, in a few amphiarthrodial joints, but usually the joints where they occur are freely movable throughout their extent, and are, therefore, called diarthrodial. The intersegmental tissue may not

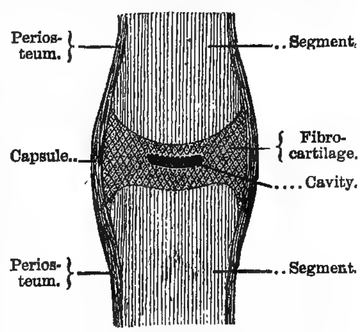


Fig. 303.—Formation of a Synovial Cavity.

be wholly obliterated by the cavity. When the movement of the segments is perfectly regular and small in amount, it may remain as a central band with a cavity on each side and ligamentous structures surrounding the whole, forming a capsule or envelope. This is a peculiarity of the articulation of the heads of the ribs with the spine (Fig. 304). When the movement is such that the articular surfaces do not correspond, a synovial cavity is sometimes formed along the surface of each segment, leaving an intervening disk of fibrous tissue, which becomes partly cartilaginous and is then known as an interarticular fibro-cartilage (Fig. 305). Example, lower-jaw joint. The disk may become thinned and disappear in the centre, leaving a ring (Fig. 306 shows this in vertical section). This occurs in the knee-joint. Its complete disappearance is shown in Fig. 307.

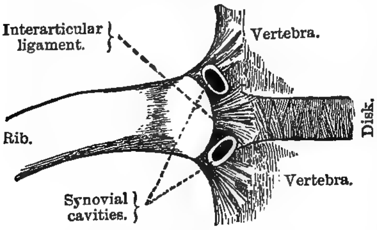
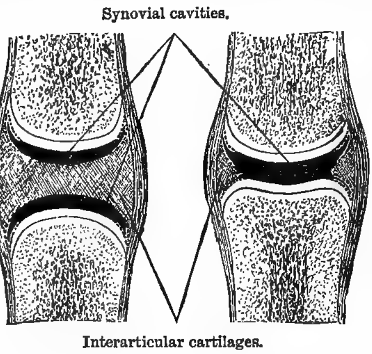


FIG. 304.—Costo-vertebral Joint.



FIGS. 305 and 306.—Formation of Arthrodial Joints.

Joints may be formed under pathological conditions, the process being similar to that just described. After fracture the ends of the bone are first united by fibrous tissue, constituting an amphiarthrodial joint, which may remain permanently, or by process of repair be converted into synarthrodial and finally disappear; or, if mobility of the apposed ends be not restrained, there may be developed a false arthrodial joint with synovial membrane and ligaments formed from the surrounding connective-tissue.

The action and relations of muscles are important factors in shaping and otherwise modifying joints. By surrounding they afford protection, and also actively assist the ligaments in holding together the apposed ends of the segments; differing in this, that their tension can be adjusted to the stress placed on the segments. They are invariably attached so as to support the articular surfaces with reference to each other, never pulling them apart. Dislocations are therefore more likely to occur if the force is applied suddenly, before the muscles can be put in action, and are rare among professional athletes. Advantage is taken of this peculiarity of the muscles in reducing a dislocation, this being much more easily done when the patient is taken off his guard, or when resolution of muscular force is produced by an anæsthetic. Expansions from the tendons of muscles strengthen and support the joints, uniting with the joint-capsule. When the strain put upon these expansions is habitually great, as in case a tendon passes over the angle made by the two segments, the connective-tissue of the tendinous expansion is liable to take on some denser form, as cartilage or bone. These appear as small nodular bodies known as sesamoids,

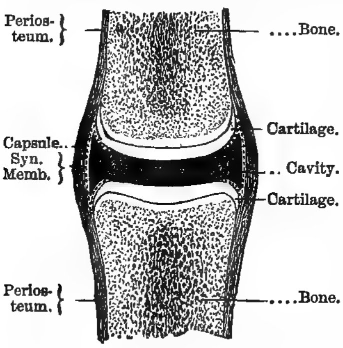


FIG. 307.—Fully Developed Arthrodial Joint.

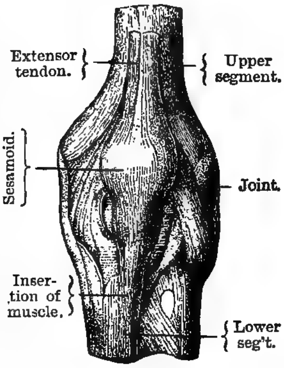


FIG. 308.—A Sesamoid (Knee-joint).

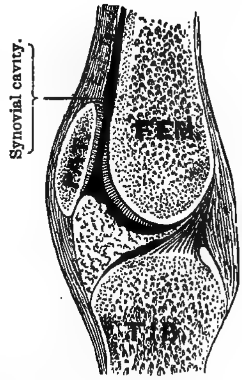


FIG. 309.—Planiform or Gliding Joint (Patello-femoral). Sliding and coaptative motion only.

and possess true articular surfaces. The patella is the largest and most notable example of these (Figs. 308 and 309). The shapes of articular surfaces depend mainly upon the direction and preponderance of the muscular force applied to the segments. The simplest movement possible is the sliding of one nearly plane surface upon another. This is the ordinary movement of the sesamoids. Joints where this is the prevailing movement are called planiform or arthrodial (Fig. 309). There are, however, no articular surfaces that are perfectly plane, there being no situation where a pulling force is applied in a continuous straight line throughout the extent of the movement. For this reason there is also found in planiform joints a slight rolling of convex surfaces on each other. This is called coaptation. When the surfaces are markedly curved a variety of movements may take place. Motion around an axis passing longitudinally through one of the segments is called rotation. Pivot-joints (tro-

FIGS. 310 and 311.—Pivot-joint (Atlo-axoid). Rotation only.

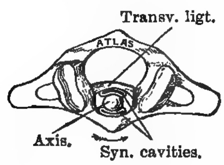


FIG. 310.—Top view.

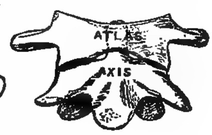


FIG. 311.—Front view.

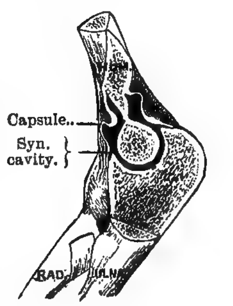


FIG. 312.—Hinge-joint (Elbow). Angular motion in one plane.

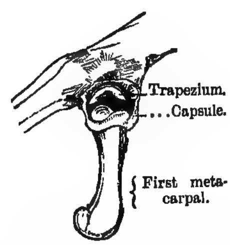


FIG. 313.—Saddle-joint (Thumb). Angular motion freest in two planes.

Arthrology.

choides) possess only this movement, and are exemplified in the atlo-axoid and superior radio-ulnar articulations (Figs. 310 and 311). Bending the segments so as to alter the angle they make with each other is called angular movement. When lateral, to or from the axis of the body or limb, it is further distinguished as adduction and abduction; when forward or backward, folding or unfolding the segments, as flexion and extension. A hinge-joint (ginglymus) is one in which such motion is allowed in a single plane only. The elbow is the best example (Fig. 312). The shape of the surfaces may allow free angular movement in some directions while limiting it to some extent in others. In the saddle-joint (Fig. 313), and the pommel-joint (Fig. 314), the motion is freest in two planes at right angles to each other. In the former, each surface is convex in one plane and concave in the other; in the latter, the surfaces are reciprocally ellipsoidal. These two classes of joints allow all movements except rotation, it being possible to perform circumduction or such swinging of the distal segment through a series of angular positions as to make it generate a conical surface. When the joint consists of a head nearly spherical received into a closely-fitting cavity, it is known as a ball-and-socket-joint (Fig. 315), in which great freedom of motion is allowed, all movements being possible.

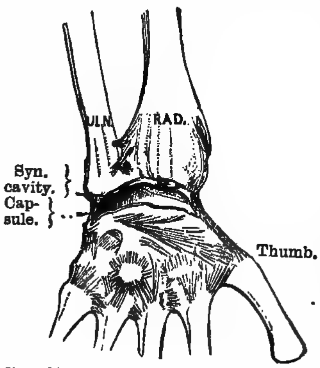


FIG. 314.—Pommel-joint (Wrist). Angular motion in all planes.

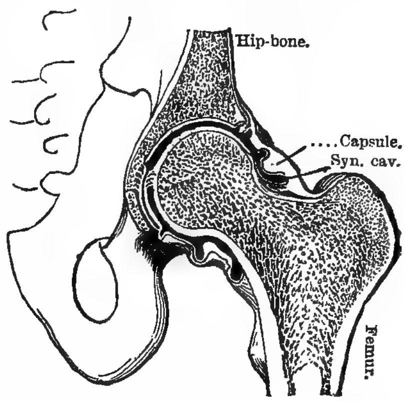


FIG. 315.—Ball-and-socket-joint (Hip). All movements.

The following table shows how joints may be classified according to a genetic system:

CLASSIFICATION OF JOINTS.

PRIMITIVE JOINTS (AMPHIARTHROSES).

- Without Synovial Cavity.
  - IMMOVABLE JOINTS (SYNARTHROSES).
    - United by cartilage. SYNCHONDROSES.
    - United by Connective-tissue. SUTURÆ.
- With Synovial Cavity.
  - FREELY MOVABLE JOINTS (DIARTHROSES).
    - Motion sliding or coaptative, surfaces nearly flat. PLANIFORM.
    - Motion curvilinear, surfaces curved. NON-PLANIFORM.
      - Rotation only. PIVOT-JOINTS.
      - Angular motion one plane. HINGE-JOINTS.
      - Angular motion freest in two planes. SADDLE-JOINTS.
      - Angular motion all planes. POMMEL-JOINTS.
      - All movements. BALL-AND-SOCKET-JOINTS.

The following is a list of the joints of the human body arranged upon the foregoing principles of classification. As in all natural classification, perfectly clear and sharp distinctions do not exist, many joints being somewhat mixed, blending the characters of two or more classes.

TABLE OF THE JOINTS.

ORDER I.—PRIMITIVE JOINTS, OR AMPHIARTHROSES.

Class 1.—*Without a Synovial Cavity.*
- Intervertebral—of bodies.
- Lumbo-sacral.
- Sacro-coccygeal.
- Sternal.

Class 2.—*With an Imperfect Synovial Cavity.*
- Sacro-iliac.
- Interpubic (symphysis pubis).

ORDER II.—IMMOVABLE JOINTS, OR SYNARTHROSES.

Class 1.—*Sutures.*
- Joints between the bones of the skull, except occipito-sphenoid and ethmo-vomerine.

Class 2.—*Synchondroses.*
- Occipito-sphenoid.
- Ethmo-vomerine.
- Chondro-sternal of first rib.
- Costo-chondral.

ORDER III.—MOVABLE JOINTS, OR DIARTHROSES.

Class 1.—*Planiform Joints, or Arthrodia.*
- Intervertebral, of articular processes.
- Lumbo-sacral, of articular processes.
- Costo-vertebral (costo-central).
- Costo-vertebral (costo-transverse).
- Chondro-sternal, second to seventh ribs.
- Interchondral, sixth to ninth costal cartilages.
- Sterno-clavicular.
- Acromio-clavicular.
- Radio-ulnar, inferior.
- Carpal—between single bones.
- Carpo-metacarpal, except thumb.
- Intermetacarpal.
- Patello-femoral.
- Tibio-fibular, superior and inferior.
- Tarsal, except astragalo-scaphoid and calcaneo-cuboid.
- Tarso-metatarsal.
- Intermetatarsal.

Class 2.—*Pivot-joints, or Trochoides.*
- Atlanto-axial.
- Radio-ulnar, superior.

Class 3.—*Hinge-joints, or Ginglymi.*
- Elbow-joint (humero-cubital).
- Phalangeal, of hand.

Knee-joint (femoro-tibial).
Ankle-joint (tibia and fibula with astragalus).
Phalangeal, of foot.

Class 4.—*Saddle-joints.*
Carpo-metacarpal, of thumb.
Calcaneo-cuboid, of ankle.

Class 5.—*Pommel-joints* (*Condyloid*).
Temporo-maxillary.
Occipito-atlantal.
Radio-carpal.
Intracarpal (os magnum with semilunar and scaphoid).

Class 6.—*Ball-and-Socket-joints* (*Enarthrodia*).
Shoulder-joint (scapulo-humeral).
Metacarpo-phalangeal.
Hip-joint (coxo-femoral).
Tarsal, astragalo-scaphoid.
Metatarso-phalangeal.

An examination of the intimate structure of adult joints involves, 1st, the ends of the segments (usually bones); 2d, the articular cartilages which protect them; 3d, the fibro-cartilages which, when present, adapt the surfaces to each other; 4th, the ligaments which prevent their separation; 5th, the synovial membranes which by their secretion lubricate the joints.

At joint-surfaces pressure and movement occasion a modification in the ordinary structure of bone. The ends are enlarged and the surfaces are of extremely compact tissue, protected by a layer of hyaline cartilage, the remains of the original cartilage from which the bone was formed. Acting as a buffer to break shocks and to prevent wear, it is invariably thickest where the pressure is greatest (see Fig. 307). Under normal conditions it never ossifies, although in old age and in persons of inactive life it becomes thinned and infiltrated with lime salts. Should it slough, the bone becomes rapidly worn smooth (eburnated) and the joint is disabled. The superficial cells of the cartilage are flattened, but in the deeper parts they multiply in the line of the greatest stress, and are therefore arranged in columns perpendicular to the articular surface (Fig. 316), in which direction a sudden shock may cause the cartilage to split. The fibro-cartilages found in joints are composed of white fibrous tissue, with sparse elastic fibres to impart the necessary resiliency. Their usual form is that of disks or rings attached mainly to the more movable segment, either by their edges (knee, jaw) or by the edge and one surface (hip, shoulder). The rings may be incomplete, enlarging the cavity on one side only (phalanges).

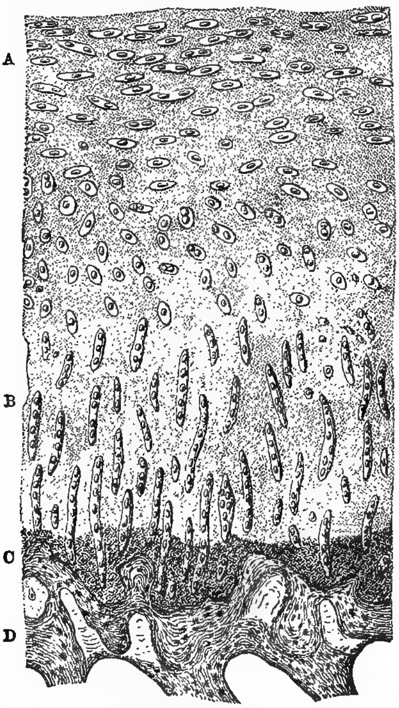


FIG. 316.—Articular Cartilage. (After Sappey.) A, flattened cells; B, cells in columns; C, region infiltrated with lime; D, bone.

The original capsular arrangement of the ligaments remains in cases where the joint is well protected by muscles and the strain is evenly distributed. In most joints, however, the stress being much greater in some directions than in others, the capsule becomes thickened to counteract it, forming bands which have received special names. Atmospheric pressure, acting against the force of gravity, assists in keeping the articular surfaces applied to each other, thus preventing a constant strain upon the ligaments. An important office of the ligaments is to limit the motion of the segments and prevent the shocks which would otherwise occur from the sudden contact of bony surfaces. In some cases they greatly economize muscular force by holding the joint in a set position. Thus, but little force is required to maintain the body erect, as it is supported mainly by the tension of the ligaments of the spinal column, by the ilio-femoral ligament at the hip, and by the posterior, lateral, and crucial ligaments at the knee; these lying always on the convex side of arcs subtended by the line of the centre of gravity (Fig. 317). Owing to their function as limiters of motion, it follows that the position of greatest relaxation for all the ligaments of a joint is one midway between flexion and extension. In case of the distention of a joint-cavity by a morbid effusion, the patient involuntarily places the joint in such a position.

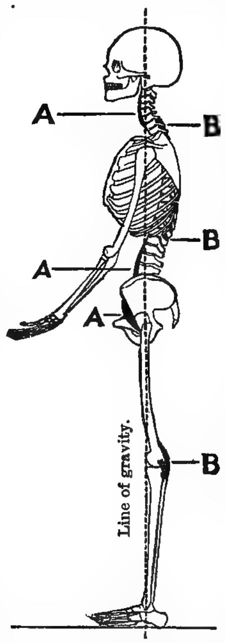


FIG. 317. — Ligaments Supporting Erect Posture. A, anterior set; B, posterior set.

Synovial membranes originate as continuous and closed sacs, but over the articular surfaces, where pressure occurs, portions of them disappear; so that, at the latter part of fœtal life, they merely line the capsule and extend but a short distance upon the cartilages of the joint. In adult age they frequently are further extended by communication with the synovial cavities of neighboring bursæ, and such communications become more frequent and extensive as age advances. They are more lax than the surrounding ligaments, being thrown into folds to increase the blood-supply and to pad out intervals, being assisted in this by interstitial deposits of fat. Along the inter-articular lines they possess villous processes, or fringes, some of which contain cartilaginous nodules (Fig. 318).

It is at or near the joints that the great vascular trunks divide, an arrangement which is probably connected with the centripetal development of blood-vessels and the bud-like formation of limbs in the embryo. The immediate supply of the joint is obtained from small vessels that anastomose freely with each other. By them the collateral circulation is established when the main trunk is occluded. From these vessels a rich arterial network penetrates the capsule to supply the synovial membrane. Abundant capillaries lie in loops along the synovial folds, and by exudation from them the synovia is formed. The articular cartilages and the compact layer of bone immediately contiguous are normally destitute of vessels, but capillaries rapidly extend into them during inflammation. The fibro-cartilages are stated by Sappey to contain vessels, and may therefore take an active part in inflammatory processes. Lymphatics are numerous near joints. Klein considers the joint-cavity itself as a lymph-space communicating directly with the lymphatics, and Arnold and Heitzmann claim to have demonstrated a system of lymph-canaliculi even in articular cartilage.

The nerves of joints are distributed mainly to the synovial membrane and the ligamentous structures. It

is probable that in these situations special nerve-endings exist, as described by Krause and Nicoladoni, for it is difficult to otherwise account for the peculiar sensibility of the structures. A ligament or a synovial membrane may be touched, cut, or pinched without giving much pain, but if it be stretched beyond its physiological limit, threatening the integrity of the joint, the suffering is excruciating, as is well known to those who have suffered from a sprain or a dislocation. Articular cartilage has no nerves, and the gnawing pain which occurs during its ulceration is probably caused by inflammatory products affecting the nerves of contiguous tissues. A remarkable law of correlation has been noted by Hilton with reference to the nerves of joints, viz.: that they also supply the muscles which move the joint and the skin over the insertion of such muscles; the whole apparatus being thus under the control of associated central influences. There is besides strong clinical evidence of this. Remak and Benedikt have pointed out the strong probability that many diseased conditions of the joints originate in irritable states of the spinal cord and of the sympathetic, and Charcot has published some cases showing remarkable atrophy of the muscles of a joint after an injury to the articular surfaces comparatively slight and inadequate to such a result. Locomotor ataxia is usually accompanied by joint-lesions. Quite recently (Ord, Belfast Address, July, 1884) it has been shown that many cases of joint disease (rheumatoid arthritis, gonorrhœal rheumatism) are so associated with disturbances of the genito-urinary tract as to make it probable that there is a reflex element of causation in these disorders.

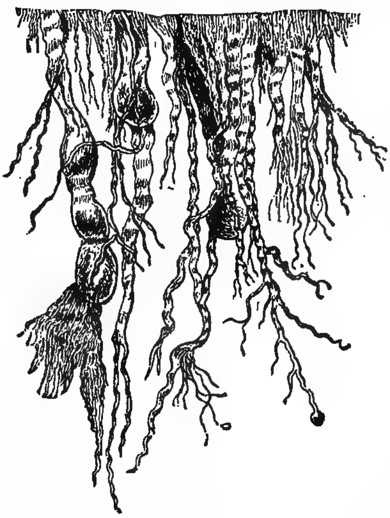


FIG. 318.—Synovial Fringes. (× 200.) (Modified from Henle.)

For the anatomy of special joints see the following heads: Ankle-joint; Clavicle, Joints of; Elbow-joint; Foot, Joints of; Hand, Joints of; Hip-joint; Knee-joint; Pelvis, Joints of; Shoulder-joint; Skull, Joints of; Spine, Joints of; Thorax, Joints of; Wrist, Joints of.

Besides the systematic works on anatomy by Quain, Gray, Allen, Sappey, Cruveilhier, Henle, Hyrtl, and Gegenbaur, the following authorities have been consulted in preparing this article:

Morris, William: The Anatomy of the Joints. London, 1879.
Turner: An Introduction to Human Anatomy. Edinburgh, 1867.
Marshall: Anatomy for Artists. London, 1883.
Humphry: The Human Skeleton, including the Joints. London, 1858.
Henke und Reyher: Über die Entwickelung der Gelenke, Sitzungsber. der Wiener Acad. der Wissensch., Bd. lxx.
Aeby: Der Bau des Menschlichen Körpers. Leipzig, 1871.
Martin: Über die Gelenkmuskeln beim Menschen. Erlangen, 1874.
Meyer: Die Statik und Mechanik des menschl. Knochengerüstes. Leipzig, 1873.

Frank Baker.

ARTHROPATHIES OF NEUROTIC ORIGIN. As far back as 1831 the elder Mitchell [1] first described peculiar joint troubles that affected individuals who had suffered from cerebral disease; and in 1846 Scott Alison,[2] of London, more fully described these sequelæ, presenting several cases in which the joints of the paralyzed side only were affected. This arthritis he believed to be due to a condition of the articular surface resulting from the diminished vitality of the paralyzed parts and the presence of uric acid, which under such circumstances acted as an irritative agent.

In 1872, and even before this time, Brown-Séquard,[3] and Charcot [4] directed attention to the really important nature of such complications of organic paralysis, and the early researches of Alison, Durand-Fardel, Valleix, Grisolle and others, have been collected and carefully considered by them during the past three or four years. Buzzard, of London, has, in his book, excited fresh interest in the study of these *arthropathies*, especially when they are connected with locomotor ataxia.

It would appear that these morbid changes are usually associated with those forms of cerebral and spinal disease in which the sensory tracts are most extensively invaded, though this is by no means the invariable rule. They are common in posterior spinal sclerosis and rare in essential spinal paralysis, an affection in which disorders of sensibility are the exception. They are rare in cerebral disease without some ascending degeneration symptomatized by *pain*, and the observations of Charcot regarding the central lesion would bear this out. Arthropathies may be either cerebral or spinal, and the former are much more rare than the latter. They have been observed in connection with coarse brain disease, such as softening, with hæmorrhage, tumor, or sclerosis; and are usually early symptoms of established cerebral mischief; especially is this true in the matter of hæmorrhage. After a period of from fifteen days to several months after the acute central trouble we find that the joints of the paralyzed hand or foot become affected—the former more often (Charcot)—coincident with the contractions which mark the advent of rigidity and secondary degeneration. In Alison's cases the knee and ankle were affected.

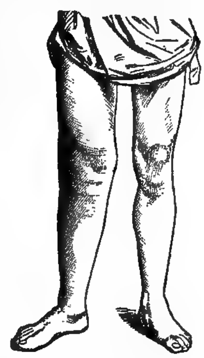


FIG. 319.—Arthropathy of Right Knee-joint. (Buzzard.)

The joint disturbances, according to my own observation, begin in one of two ways: 1, Suddenly, the large joints being affected; 2, slowly, the joints of the hand and foot being the parts attacked. In the first form there is within a few weeks a rather suddenly-developed swelling, which is unattended by any marked rise of temperature—at least by any such rise as we would expect to find in an acute arthritis of purely rheumatic origin. There is but little local heat and pain, but a great deal of *soreness* when the limb is moved. Jarring produces only inconsiderable suffering. I have never met with the degree of pain described by Brown-Séquard. There is more or less pain produced by pressure over the tendons, the sheaths of which seem to be involved. The joint is greatly swollen, the enlargement being made much more prominent in old cases by reason of the atrophy of muscular masses in the vicinity. There seems to be a deep involvement of the joints and of adjacent parts, and though there may be a synovitis, it is of a low grade, and, as Buzzard [5] has pointed out, there is really great tumefaction, which characterizes the familiar form of chronic synovitis, in which there are three points of swelling, viz.: above the patella, and on either side of the ligamentum patellæ.

The appearance of the affected joint is peculiar. There is a duskiness and hardness in the beginning, and a cold, "white hardness" of the swollen limb in the old cases.

In some cases there is, after a few days or weeks, a subsidence of the swelling, and the development of osseous changes to be presently described.

The occurrence of *spinal arthropathy* may follow a variety of conditions. As has been pointed out by Mitchell, it may be connected with Pott's disease, with myelitis (Gull), with tumors of the gray substance of the cord (Buzzard), with posterior spinal sclerosis (Charcot), and with traumatic injury of the cord (Vignes and Joffroy).

According to Charcot the condition is an early compli-

cation, especially of posterior spinal sclerosis. So far as my own experience (and I think that of Buzzard) is concerned, the condition is one that belongs to the late stages of the disease. It is quite true that in acute myelitis we may have a rapidly-developing arthropathy, but with tumor or locomotor ataxia the affection is a much more slow affair. Charcot believes that those arthropathies which affect the upper extremities in the disease under consideration are always secondary to others involving the lower extremities, and come only late in the disease, as a result of extension of the morbid process. Buzzard reports a case which contradicts this. I have myself seen one case of the kind.

The enlargement in the chronic variety is slow, and a point is finally reached when deep destructive processes begin, the articular surface of the bones being worn away or absorbed, so that movement of the joint on manipulation will produce a peculiar creaking or cracking sound; and when the joint has for some time been the seat of the trouble it is common for luxation to occur. The position of the extremity as it lies upon the bed is peculiar, and the patient often presents a most strange deformity. Happily the arthropathy need not always go on to this stage, and it occasionally happens that cures are made. On the other hand the erosion and destruction may be very rapid. Charcot says: "Even within two weeks, or sooner, the 'craquements' may be detected, which indicate a profound alteration in the articular surfaces." At the end of three months the head of the humerus in one of his cases was found to be almost completely destroyed.

PROGRESSIVE ARTHROPATHY.—There is a form of arthropathy of a progressive nature of which I have seen but

FIG. 320.

one true case, and I do not know that any other has been reported. In the patient who came under my notice, a sudden swelling of both ankles occurred, with little or no pain, and in less than one year both thumbs and ring fingers became in turn affected, and ultimately both little fingers. The metacarpal joints were the seat of a hard and quite extensive swelling with some general œdema, more marked on the palmar surface. The patient could flex neither the thumb nor the other affected fingers, but the second and third fingers seemed to be unimpaired so far as their mobility was concerned. The ankle-joints were lax and some absorption of bone had evidently taken place. There was no history of gout in this case. The patient's urine was clear and passed in large quantities, and I had no reason to suspect the uric acid diathesis. The affected parts had, *before* the appearance of swelling, been the seat of neuralgic pains. The right pupil was smaller than the left and there were interesting nutritive skin changes, and a peculiar slowness of gait.

The history of arthropathies in general furnishes us with points which enable us to make a comparatively clear diagnosis. The antecedent cerebral or spinal disease is a determining factor, and the peculiar nature of the joint affection itself is conclusive. What I have already said about the possibility of confusing the condition in question with ordinary chronic synovitis it is unnecessary to repeat. I may, however, remind the reader that the effusion is always beneath the muscles, the skin has a polished appearance and presents no appearance suggestive of inflammation. There is often great embarrassment in flexion, though, as in Buzzard's case, extension is not interfered with. There is no pitting at the joint. In the case alluded to, he made an application of the electrodes of an induction battery over the quadriceps muscle, just above the patella. When the swelling was very great, he obtained a powerful contraction, which proved the fact that the muscle was superficial to the fluid. The affection resembles sometimes *arthritis deformans*, but it rarely involves the hip-joint. It is of sudden appearance, is often cured, the effusion is greater and the swelling more general than in the latter disease, and there are luxations as the result of erosion, which is not the case in rheumatoid arthritis.

Charcot has found evidences of a true synovitis—multiplication of nuclear elements, and thickening of fibrous tissue—increase in size and number of capillary vessels, and an increased amount of exudation containing leucocytes. In this case he found macroscopic lesions of the cartilages or of the ligamentous parts.

In the cases of cerebral origin a variety of interesting changes were found by Alison, but none threw much light upon the pathology of the condition, and the same thing may be said of the autopsies presented by other observers. Charcot, however, found that in locomotor ataxia there was a disappearance upon the same side of the body of the posterior lateral group of large cells in the anterior cornu. A case presented by Joffroy and himself

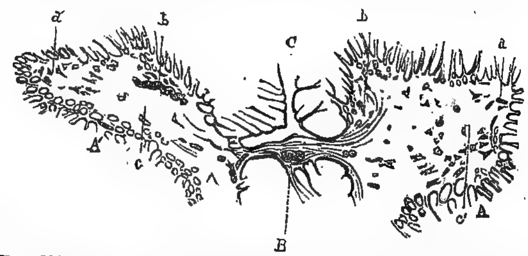


FIG. 321. (Charcot.) A, A′, right and left anterior horns; B, posterior gray commissure and central canal; C, anterior fissure; *b*, *b′*, anterior internal group of great cells; *a*, *a′*, anterior external group of great cells; *c′*, posterior external group of great cells on right side; *c*, locality where corresponding cells have disappeared on left side.

was carefully studied, and it was found that the anterior gray horns were "remarkably atrophied and deformed." Fig. 321 represents a section made through the anterior horns in the cervical cord of a patient who presented an arthropathy of the shoulder-joint. In a second case examined by these investigators, in which the knee-joint was affected, it was found that the anterior gray substance in the lumbar region had undergone a conspicuous alteration. Charcot does not believe that this degeneration is a result of functional inertia, because in his cases there was considerable freedom of movement, and the central appearances did not resemble in the least those found after amputation.

The *prognosis* of arthropathy is by no means good, although it has been claimed that cures have been effected. The benefit of therapeutic measures must be shown at an early period, and if the morbid process has gone so far as to result in destruction of the articular surfaces, little or nothing can be gained by any treatment. It must be admitted that in spinal disease, especially when the arthropathy is associated with gastric crises, and other symptoms suggestive of advanced cord destruction, the prognosis is well-nigh hopeless.

The treatment of these joint affections consists in the

exhibition of the iodide of potassium in very large doses —even one-half, or in some cases two-thirds, of an ounce daily in Vichy water—and the free application of the actual cautery to both the spine and the affected joints. Careful bandaging and the application of straps of the ammoniated-mercury plaster are of use, while perfect rest is indispensable. *Allan McLane Hamilton.*

[1] American Journal of the Medical Sciences, vol. viii., 1831, p. 55.
[2] London Lancet, 1846, vol. i., p. 277.
[3] London Lancet, July, 1861.
[4] Leçons sur les Maladies du Syst. N., 1872-73, p. 100 et seq.
[5] Diseases of the Nervous System, p. 214 et seq.

ARTIFICIAL EYES (Fr., *Œil artificiel;* Ger., *Künstliche Auge*).

History.—Since very early times artificial eyes have been known and used, yet no connected history of their use can be distinctly traced. They were first made out of metal; copper, silver, and gold being the materials most commonly employed; these metallic disks were painted to represent the natural organ. A painted imitation of the eye and eyelids was sometimes applied over the front of the orbit, being kept in its place by means of a steel spring passing around the temple to the opposite side of the head. This exceedingly crude and inconvenient device was adopted in the days of Ambroise Paré.[1]

It is thought by some that artificial eyes were first made during the reign of Ptolemy II., surnamed Philadelphus (309 B.C. to 247 B.C.). The Egyptians were the first to make use of them, and mummies are occasionally discovered in whose orbital cavities such eyes are still to be found. At one time balls of glass were used instead of the present shell-shaped eyes. These glass eyes were not only made for the human being, but were used in statues, for Pliny[2] tells us that on the tomb of Hermias, a prince of the island of Cyprus, there was a marble figure of a lion having eyes of emerald. In the great marble lion discovered by Mr. Newton near Cnidus, and now in the British Museum, there are in the place of the eyes deep sockets, which probably, like those of the Cypriote lion, were filled with colored glass. It was not until the introduction of porcelain, in the sixteenth century, that any great stride in the making of eyes took place, and from this time to the nineteenth century the methods of manufacture were kept secret by the makers. Even at the present time each manufacturer has a special method of preparing his glass or "crystal," as he terms it, which is known only to himself. The Parisian eyes were for a long time considered the best, and were made by the family of Hazard-Mirault and by Desjardins, and their manufacture was so perfect in 1820 that, in the "Dictionnaire Médical," the following statement occurs: "L'art de fabriquer des yeux artificiels est arrivé à un tel point de perfection, qu'il paraît impossible d'aller aujourd'hui au delà."

To Boissonneau, however, is due the credit of placing this industry on a proper basis, and of perfecting many improvements between the years 1840 and 1866. At one time the name of the maker was painted upon the eye, so that it might act as an advertisement; again, a small hole was made in the edge through which a string was put to catch hold of in removing the eye from the eyelids. Artificial eyes have been made out of wax, celluloid,[3] and vulcanite;[4] and not long since the writer saw a horse with an eye made of horn. At the present day, however, glass is the only material employed in their manufacture. Shakespeare makes *King Lear*, in his adjuration to the unfortunate *Gloster*, say:

> "Get thee glass eyes;
> And, like a scurvy politician, seem
> To see the things thou dost not."

It is related that, at a period of general distress, two citizens of Latium carried their artificial eyes to the public treasury in the same manner that the French women offered their trinkets as patriotic gifts during the first Revolution. It is to be presumed that these offered eyes were made of gold. A Haytian general, having lost his eye in battle, sent to Paris for an artificial one. The maker sent in return one of his best. Shortly after the general returned it, with the remark that the eye was too yellow, and recalled to his mind the Spanish flag, adding at the same time that he would wear only an eye having the colors of his country. The maker thereupon made one with red and green predominating (these being the Haytien colors). This so pleased the general that instead of wearing the eye as intended, he added it to his collection of medals. Similar cases are recorded where such eyes have been worn as jewels.

Seventy thousand persons in the United States are said to wear artificial eyes.

Manufacture.—The first glass eyes were made in Paris, but just as good eyes can be now obtained in England and in this country. In this city are at least two makers, to one[5] of whom I am indebted for some facts in regard to their manufacture. The art in manufacturing false eyes consists not so much in the shaping, coloring, etc., as in the preparation of the material from which the shell is made. It is necessary to guard against brittleness, and at the same time to procure a substance that will resist the action of the conjunctival secretions.

The French makers use butter of antimony, chalk, borax, and uranium; others use manganese, oxide of tin, arsenic, and fine flint. A London maker uses a spar, avoiding metallic oxides; this, in order to be made ductile, needs to be subjected to an intense heat for thirty-six hours. It is in the preparation of the glass and in imparting proper consistency to it that all the difficulty lies. The artist is seated before a table with a blowpipe attached, the flame being regulated by means of hydraulic pressure, so that it is strong and steady. To this heat the tubing, closed at one end, is subjected; as soon as it is at a white heat the maker blows the ball and shapes it, then at the proper moment he takes a stick of pigmented glass and places a drop on the summit of the ball; it is then heated again and at the same time he flattens it. This colored glass represents the iris. By a process of teasing the iris is made to have a blending of colors—this part of the work is really artistic: then a darker stick of glass is taken and fused to the centre of the iris, making the pupil; after this the cornea is formed of transparent crystal. The colored tubing is now drawn out until it has only the diameter of the finest silk thread, and, by using its melted tip as a brush or pencil, the delicate shadings and vein tracery are produced. After this the ball is heated, is cut from the stem on which it was previously held, and its sharp edges are rounded off. When completed the shell has an ovoid form, one surface being convex and the other concave, and its surface is smooth and enamelled. Such eyes wear well, whereas the cheaper ones do not. The pupil in the artificial eye is made of the average normal size, or, when made to order, of the size of the pupil of the patient's eye in daylight. Glass eyes are made in a great variety of forms, to suit the peculiarities of special cases. One well made and matched is very difficult to detect and will last from one to two years, at the end of which time, the surface becoming rough from the action of the secretions on the enamel, it becomes necessary to procure a new one. The only sure way to obtain an eye perfect in shape and color is to come personally before the maker, and to sit as for a painting.

In order to fit a person without making a special eye, it is necessary to have on hand a collection of several hundred eyes, as the variations in point of color and of shape are many. Artificial eyes are also made in "rights" and "lefts." Some makers have a very large assortment from which they fit their poorer patients, or at times they hire out an eye to be worn on a special occasion, the wearer not usually caring for his blemish. The actual cost of material used in making an eye is fifty cents; the skill, however, requires many years' practice. The cost of artificial eyes varies from two to fifteen dollars, depending largely on the wealth of the purchaser. In old times they were very expensive and were attainable only by persons of means.

The Application of Artificial Eyes (*Prothesis Oculi*, from πρό, "before," and τίθημι, "I put").—Artificial eyes are worn by two classes of patients; those in

whom the eyeball still exists in the orbit, but is shrunken, and those in whom the eyeball has been enucleated.

Very few, however, now wear the shell over the shrunken globe, as it is considered bad practice, cases of sympathetic inflammation of the fellow eye having been known to follow such a procedure. In any case where it is purposed to wear an artificial eye, the rule to-day is, first the removal of the blind eye and then the application of the false one. This practice should be invariably followed.

The use of an artificial eye should not be allowed until two or three weeks after the enucleation, when the cicatrix has become firmly united. If an eye has been removed on account of the supervention of sympathetic inflammation in its fellow, care should be taken not to insert the artificial eye until all evidences of such trouble have disappeared.

Mode of Introducing.—Place the left hand flat upon the forehead, with the fingers down, and with the two middle fingers raise the upper lid toward the eyebrow; then, with the right hand, push the upper edge of the artificial eye beneath the upper lid, which may be dropped upon it; the lower lid is now raised over the lower edge of the eye with the right hand. The prominent part of the eye should be turned toward the outer canthus, and it is best to dip the eye in water previous to its insertion. For some days the artificial eye is to be worn only during a few hours, but by degrees the length of time during which it is worn may be increased, until the patient can bear its continued presence throughout the entire day. It should, however, in all instances be removed at night.

To Take the Eye Out.—Draw the lower lid down with the middle-finger of the left hand: then, with the right hand, insert the tip of a bodkin or of a glass-headed pin beneath the lower margin of the artificial eye and gently raise the margin over the lower lid, when the eye will be ready to drop out. At first most patients hold their heads over a bed, so that, if the eye should fall, it would escape being broken. After a little practice no difficulty is experienced either in the insertion or in the removal of an artificial eye.

The first eye should be smaller than the subsequent ones. A properly adapted eye performs the same motions as the sound eye. In the use of an artificial eye the strictest regard to cleanliness must be observed; every twelve hours the eye must be taken out and freed from the mucus which adheres to it and accumulates in its cavity. The conjunctival sac should be bathed with tepid salt water, and if there is any tendency to conjunctivitis, a lotion of five grains of alum to the ounce of water may be used with good effect. If there are any conjunctival bridles in the orbital space a specially made eye should be worn.

A case [6] is on record in which the wearing of an artificial eye produced sympathetic inflammation of its fellow, although the shrunken globe had been removed. On the other hand, Dr. Chisolm, of Baltimore, has reported a case in which an artificial eye had been worn for twelve years without ever being removed, and with no difficulty. Vulcanite and celluloid eyes being less liable to break have been made for the use of children. Artificial eyes may be obtained from instrument-makers and opticians in any city, and in large cities from the manfacturers direct. This latter plan is the best and most satisfactory.

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William Oliver Moore.

[1] Œuvres d'Ambroise Paré, liv. xxiii., chap. i.
[2] Nat. Hist.. xxxvii.. 5, 17.
[3] Klin. Monatsblät. für Augenheilkunde, September, 1881.
[4] Centralblatt für pracktische Augenheilkunde, Jahr. v., 1881.
[5] Mr. Gouglemann, of Pape & Gouglemann, New York City.
[6] R. L. O. H. Repts., vol. vi., 2, 123.

ARTIFICIAL LIMBS. These are appliances designed to supply the place and to perform the functions of members which are wanting, either from congenital defect or as the result of injury or surgical operation. That branch of mechanical surgery which has for its object the supplying of these parts is known as prosthesis or prothesis, and the parts supplied are called prothetic apparatus. It is proposed in this article to treat of prosthesis as related to the upper and lower extremities only, leaving out of consideration other parts, the eyes, the nose, teeth, etc., deficiencies of which may be more or less effectively compensated for by artificial means.

Substitutes for amputated legs have apparently been used from remote antiquity, but up to within comparatively recent times they were of the rudest sort, consisting simply of a crutch or of a wooden stump, in which no attempt was made to conceal the absence of the member, or to render locomotion in any way graceful by means of joints in the support. The first mention of an improvement of this sort is by Ambroise Paré, in the sixteenth century, who speaks of an artificial leg provided with joints at the knee and ankle. Verduyn, a Dutch surgeon, in the latter part of the seventeenth century, was apparently the first to construct an artificial leg in which the weight of the body was supported by lateral pressure on the stump rather than on the flexed knee. He made a wooden foot, to which was attached a copper case, lined with chamois. This received the stump, passed up over the knee, where it was jointed, and embraced the thigh with a broad belt.

But little progress was made from this time until the beginning of the present century. Heine, of Würtzburg, constructed in 1810 a very efficient support, which was, however, exceedingly complicated. The most noteworthy improvements which his apparatus showed were a ball joint for the ankle, and an attachment to the trunk by means of a corset with pelvic straps. In 1816 Pott, of Chelsea, constructed a prothetic apparatus, since known as the Anglesey leg, so called after the Marquis of Anglesey, for whose benefit it was devised. It was formed out of a solid piece of wood, hollowed out to receive the stump, and provided with a steel joint at the knee. The ankle-joint was made of wood, to which motion was communicated by strong cat-gut strings posteriorly and a spiral spring anteriorly. He also made a "riding" leg for the same person, in which the part resting against the horse was made of thick but yielding leather. F. Martin and Charrière about 1840 devised the self-locking knee-joint, in which the joint is placed posteriorly to the axis of the limb, so that the knee cannot bend when the weight of the body is thrown on it in extension.

It is to the ingenuity of American manufacturers that some of the greatest improvements in recent years are due. The writer has been unable to acquaint himself with the peculiarities of all the different styles of artificial legs made by the twenty or thirty Government manufacturers in this country, and their enumeration would be of no practical utility. While not desiring to institute any comparisons or to recommend any one maker's apparatus to the prejudice of others, the writer wishes to mention the characteristic features of only a few, not necessarily the best, but those with which he is most familiar. The Selpho leg is a modification of the old Anglesey apparatus. It is made of wood, and the knee-joint is formed of a broad convex steel plate fitted into a lower concave surface covered with smooth leather. In the ankle-joint the effects of concussion in walking are obviated by means of India-rubber buffers, and the sole of the foot is also covered with rubber. The leg made by A. A. Marks has no joint at the ankle, but the foot is made of solid rubber, with a small core of wood. It is claimed that the elasticity of the rubber obviates the necessity of any joint at the ankle, while the rubber is sufficiently yielding to permit the foot to accommodate itself to any little inequalities of the ground. The Palmer leg is constructed of wood, with wooden joints, provided with spiral springs, to straighten them after flexion. At the knee is an excentric hinge, to prevent

sudden flexion when the individual stands. The Bly support has a ball in the ankle-joint, by which lateral as well as antero-posterior motion is effected. It is claimed that a person wearing an artificial limb of this construction is enabled to stand and walk on any inclined surface with almost as much facility as one provided with his natural members. The Hudson leg is constructed with excellent and firm joints, having springs of elastic webbing instead of steel. The elastic cords are so arranged that as the knee is flexed the anterior portion of the foot is elevated, thus raising the toes well from the ground during the forward swing of the leg. There is no lateral ankle motion in this apparatus. The leg invented by C. A. Frees is provided with an ingenious arrangement for securing lateral ankle motion. This consists of a double joint, an upper one with antero-posterior motion, and a lower one with side movement. A very strong elastic cord is attached to the heel to serve as an artificial tendo Achillis. This lateral motion at the ankle, provided for by several of the makers mentioned, would seem to be a valuable improvement in the construction of artificial legs, allowing as it does the sole of the foot to rest squarely on the ground, whether it be on a plane surface or on the side of a hill or other inclined plane, and thus preventing a strain upon the instrument. But in practice, those who use a leg without lateral ankle motion appear to experience little or no inconvenience from its absence.

Any degree of loss may be compensated for by an artificial limb, from the portion of the foot in Chopart's amputation to the entire limb in amputation at the hip-joint. For the latter, the late Dr. E. D. Hudson devised an artificial stump a few inches in length which was used to steady the apparatus. Two artificial legs may be worn with almost as much ease as one. The prothetic support is not usually applied so as to receive the entire weight on the end of the stump, as it is found that such continued pressure can seldom be borne, but the upper portion of the support is so fashioned as to fit smoothly and accurately over the limb, embracing it snugly on the lateral surfaces, thus distributing the weight over the entire surface and end of the stump. A leg is usually retained in position by a strap passing up over the opposite shoulder. In applying a support below the knee, however, it is usually sufficient to prolong it above the joint by means of two hinged lateral bars attached to leather flaps lacing securely about the thigh. In the case of children it is not necessary to wait until they have attained their growth before providing them with apparatus, since most makers supply an extensible support for growing persons, which can be lengthened from time to time in order to keep pace with the growth of the opposite limb. Such an apparatus will usually require to be renewed about once in three years. In adult life, the period of use for an artificial leg is from five to ten years. The United States Government gives the soldiers and sailors who lost limbs in the late war, a new support once in five years. Artificial feet are not infrequently used when a limb is shortened, as a result of hip-disease or from any other cause, in order to conceal the deformity and make up the deficiency in the length of the member. The apparatus is so applied, that the weight of the body is borne on the sole of the natural foot and thus no inconvenience is felt from its use. A support of this kind is in many respects preferable to the high-soled shoe or patten usually employed.

We find little mention of artificial arms or hands before the beginning of the present century. There is in existence an iron hand, weighing about three pounds, which was constructed for a knight in the early part of the sixteenth century. The fingers could be flexed to any desired extent by the other hand and would remain in this position until released by pressing a knob on the ulnar side of the hand ; extension of the thumb was effected by pressure on a similar knob on the radial side. A century later we find hands, resembling in shape the natural member but without motion, were made of leather. In 1812, Pierre Ballif devised a hand in which the fingers were maintained in a state of flexion by means of springs, but were extended by cords when the arm was raised or carried backwards. Most of the artificial hands of the present day are simply modifications and improvements of Ballif's hand, motion at the wrist and fingers being obtained by cords which are tightened or relaxed by motions of the elbow or shoulder. The Marks hand, like the foot of the same manufacture, is made of rubber without joints. A patient with a good artificial hand can perform many little acts, such as writing, picking up small articles, and the like, in which not much strength is required; but for heavy work an apparatus of this kind is, of course, entirely unsuited. This difficulty is overcome, however, by making the hand so that it can be detached, and so that a hook or ring, knife, fork, brush, etc., can be inserted into the arm attachment. The special tools needed for various trades may in like manner be fastened to the arm, so that a mechanic or a laborer may, with a little practice, do all but the finest work with nearly as much ease as with the tools held in his natural hand.

It is best, when practicable, that the measurements necessary for making and fitting an artificial limb be taken by the manufacturer; but when this is for any reason impossible, accurate plaster casts should be taken of both the stump and the opposite sound limb and sent to the maker. Most manufacturers will also send a chart with directions for measurement on application. It is not necessary to wait for any length of time after amputation before securing an artificial support; indeed, the sooner this is obtained after the wound is thoroughly healed the better it is in many respects. The cost of an artificial leg and foot varies, according to the length and the maker, from $50 to $125, and of an arm and hand from $40 to $75. A single arm-stump with a socket at the wrist for the insertion of various tools and small instruments may be obtained for $15 ; and the implements accompanying it cost each from $1.50 upward. More detailed descriptions of the different kinds of apparatus and of their cost may be obtained by writing to the individual manufacturers.

The following list is given with some hesitation as it is of course only a partial one, and the writer does not wish to imply that there may not be better manufacturers in the country than these. But general practitioners have usually so slight a knowledge of this branch of industry, that the following names of well-known and reputable manufacturers are given for their convenience: C. A. Frees, 737 Broadway; A. A. Marks, 691 Broadway; H. W. Shaw (successor to Dr. E. D. Hudson), 1280 Broadway, New York City; George R. Fuller (successor to Dr. D. Bly), 42 State Street, Rochester, N. Y.; Marvin Lincoln (artificial arms, hands, and fingers only), 8 Hamilton Place, Boston, Mass.

(For many of the historical facts contained in this article the writer is indebted to the excellent paper on "Künstliche Glieder," by E. Gurlt in Eulenburg's "Real Encyclopädie," vol. vii.) *Thomas L. Stedman.*

ARTIFICIAL RESPIRATION. The term artificial respiration is now used to indicate certain methods of setting up respiratory action after it has been suspended through some failure of the respiratory or circulatory apparatus. Thus the lungs may have been suddenly deprived of air, as in drowning, strangulation, or occlusion of the air-passages by an external or internal cause. Possibly the individual has inhaled something that retarded or arrested oxidization (poisoning by carbonic acid gas, chloroform, ether, or some volatile gas); or the poison may have influenced more directly the respiratory or cardiac action (poisoning by opium or its alkaloids, hydrocyanic acid, strychnia, woorara, snake-bite); again, hæmorrhage may have reduced the vital power to a minimum; or finally a nervous shock may have been sustained, as by a blow or fall.

In most of these instances artificial respiration is the method that is most successful in its results; in some of them it is not of primary value, but in all it is of material service. Thus in cases of strychnia poisoning, Rosenthal, Langley, and others have shown that it may be relied upon for prompt results (*Lancet*, ii., 1880, p. 543), and Clarke (*Rankin's Abst.*, ii., 1862, p. 62) has used it effectually on several occasions in heat-stroke, though conjointly with other remedies. Schiff found it satisfactory in cere-

bral hæmorrhage, where consciousness had been lost for twenty minutes (*Lancet*, ii., 1875, p. 500). (See articles Heatstroke and Cerebral Hæmorrhage.)

Artificial respiration is a useless resort, however, after the heart has ceased to beat. But when there is the faintest flutter in the præcordial region we should apply it and hope for success. Even in such desperate cases electricity has been found less useful, and even sometimes harmful, since a too powerful electrical current may induce cardiac paralysis. If electricity be used, there is greater probability of success from faradizing the diaphragm by applying one pole at the base of the neck over the phrenic, and the other over the seventh intercostal space (see article on Electricity). Nor can transfusion be compared with artificial respiration in efficacy. Its advantages appear to have been only temporary (Richardson: *British and For. Med.-Chir. Rev.*, i., 1863, p. 478). (See article Transfusion.)

There may be instances, but they are probably rare, in which blood-letting is of primary value, as in cardiac paralysis, dependent on a dilated right ventricle. This is recommended by Kidd (*Med. Times and Gazette*, ii., 1861, p. 362). It is also possible that tracheotomy will occasionally take precedence over other measures, for House has recorded two cases of chloroform-poisoning where laryngotomy restored respiratory action after Sylvester's method had been ineffectually applied. If we were always able to distinguish between respiratory and cardiac failure we should be able to proceed with better chances of success. In doubtful cases it is well to remember that our attempts should be primarily devoted to the syncope, rather than to the apnœa. Apply the hot and cold douche alternately and rapidly to the chest. Titillate the præcordial region, drop irritating substances, such as croton oil (two minims), on the root of the tongue, and lastly, tickle the nostrils with a feather, straw, or anything of the sort that is at hand. Theoretically this last procedure affords us the best opportunity of arousing the dormant nervous system, since, according to Schirmer (*Centralblatt*, February, 1881), the fifth nerve is most likely in such accidents to yield a reaction under electrical stimulus, because it retains its sensibility longer than any other nerve. The various methods of performing artificial respiration will be described in the section upon Drowning, for with slight modifications any single plan is applicable to all cases, whether of poisoning, heatstroke, hæmorrhage, or of suspended respiration or circulation from any other cause.

Resuscitation of Persons Apparently Drowned.—There is a general understanding among the best authorities, that when persons are drowned the term *drowning* is apt to cover a good many conditions that separately or together determine the fatal issue. In the first place, the element of fear is a factor of prime importance and robs the individual of much hope when in danger. For, so soon as presence of mind is lost violent struggles for air will inevitably ensue and large quantities of fluid will be swallowed, a considerable portion finding its way into the pulmonary air-passages. Suffocation naturally follows.

Or it may be that the unfortunate individual makes little or no effort to save himself, as when a person who is profoundly intoxicated falls into the water, for then he is apt to go straight to the bottom, never to rise until life is extinct. In a similar way, the same result may follow, in a certain number of cases, when the victim of sunstroke, apoplexy, epilepsy, or of any sudden attack of unconsciousness falls into the water, or has his attack while bathing. In this way the occasional instances of good swimmers being drowned in shallow water admit of a ready explanation. Sometimes the fatal result may be brought about directly by another sort of a complication, as when a person falls, is thrown, or dives from a height into the water and strikes some solid object beneath the surface. In corroboration of this statement almost any one will remember to have known of some person meeting with a severe injury by striking an unseen object, when diving into deep water.

Attacks of fainting or vertigo will also, for like reasons, hasten death, and so it happens that from a variety of separate causes, or from a combination of two or more, life may become extinct in a comparatively short space of time—in less than a minute, or in a very few seconds. Yet it must be remembered that these facts do not militate against others which are supported by the best of evidence. For it is a matter of observation, having been attested by thousands of competent observers, that there are men and women who in the calm and full exercise of their faculties and health may fill their lungs with air, submerge themselves, and remain under water several minutes, long enough, certainly, to kill an ordinary person, not accustomed to perform such a feat. Such experts may, we know, repeat the experiment frequently, remaining under water from two to three minutes, or perhaps more, at each submersion, and yet retain unimpaired health.

In order to fully realize the nature of this distressing accident, drowning, and the plan of treatment for restoring suspended animation, we must refer to the teachings of experiment and to multiplied observations. These point directly to the one conclusion, that water enters the lungs of drowning persons and thereby causes suffocation. In the first place, water combined with mud, sand, and gravel, has been found in the air-passages. Further, it has been shown that such matters entered the system before life was extinct, by experiments in the lower animals, in which it was demonstrated that when death took place slowly, and under conditions favoring the entrance into the air-passages of foreign matters, these bodies were actually found there after death; while, on the other hand, most experimenters failed to find such substances in the lungs when the animals had been thrown dead into the water, unless they had fallen into positions specially adapted to facilitate the ingress of water.

The importance of realizing the value of these experiments is very great, as they plainly point to certain measures that we shall emphasize in the matter of treatment. For if death can be caused by the inhalation of water into the lungs, as is the common opinion, backed by good evidence, then it should be a prime object to empty the lungs as expeditiously as possible; and this principle has been accepted by most of those who have devised special methods for resuscitating the drowned. Of these there are many in vogue. It is a matter of regret that the best of them are not generally known to members of the laity, as these persons are the ones whose lot it usually is to attempt resuscitation. Though hanging by the heels, which is a popular plan for getting rid of the water, is not extensively practised in civilized communities, it is probably not out of date among the ignorant, and will still be resorted to, even though it may cause apoplexy. Rolling on a barrel, also, is still recognized as a ready method of inducing artificial respiration, though it has caused rupture of the liver and probably harm to other internal organs. It is to be hoped that these inappropriate, hazardous, and barbarous methods will, before long, be permanently abandoned, and a systematic effort be made in our public institutions to teach some one of the good methods that can be intelligently applied by non-professional persons. The best of these are often associated with the names of those who introduced them to general notice. Accordingly there is Marshall Hall's method, Sylvester's method, that of Howard, etc.; others, again, are known as the Michigan method, the Hot-water method, etc.

Marshall Hall's plan is as follows: The body is placed on one side and alternately rolled on its face to compress the chest, and then on its back, to allow the elastic walls of the chest to return to their normal position, and thus to permit the entrance of air into the lungs (Figs. 322 and 323). This method is unsatisfactory, because it is incomplete. Under any circumstances it is far inferior to any of those about to be described.

Sylvester's plan is as follows: The arms are grasped at the elbows, drawn above the head, and kept there for two or three seconds (Fig. 324). Then this manœuvre is reversed for the same length of time, and the arms are pressed against the sides of the chest (Fig. 325).

This to-and-fro movement is to be repeated about fifteen or sixteen times a minute, until the individual begins to breathe naturally

Appropriate as this method may be, it will be shown that

Artificial Respiration.

it is far from complete, and alone will accomplish little, for the mouth should, if possible, be kept open and the tongue be pulled out, so that the air can pass readily in and out through the mouth rather than through the nostrils, which latter cannot safely be depended on. According to Sylvester's experiments (*Rankin's Abstract*, 1858, ii., p. 356), ten times more air is admitted to the chest by

Fig. 322.—Author's Method (First Position, Patient lying Prone). Right forefinger depressing the tongue; left hand pressing the diaphragm upward.

this method than in Marshall Hall's. It is best during the operation to raise the shoulders slightly, because this movement raises the vital capacity of the chest to its maximum. When the hands are being carried up, mouth to mouth insufflation may be resorted to. But the diaphragm alone is competent to carry on respiration in ordinary life.

With this principle in view Dr. Benjamin Howard has advocated a better plan. It is as follows: The individ-

Fig. 323.—Author's Method (Second Position, Patient on the Back). Right forefinger still depressing the tongue; left hand still pressing the diaphragm upward.

ual is first turned on his face, while at the same time a large bundle of clothing (which naturally is apt to be at hand) is placed beneath the stomach. Pressure is then brought to bear upon the spine as long as fluid escapes from the mouth. Then the individual is rolled over again on his back, and the bundle of clothing is placed beneath his back, so as to raise the pit of the stomach above the level of any other part of the body.

Fig. 324.—Sylvester's Method (First Position). Patient's arms extended to allow the entrance of air into the chest.

The mouth should then be opened and the tip of the tongue drawn out of the corner of the mouth. The arms should also be raised above the head. The operator then kneels beside the individual's hips, or astride of them, and with the balls of his thumb resting on either side of the pit of the stomach, he lets his fingers fall into the grooves between the short ribs, so as to allow him to firmly grasp the waist. Now, using the knees as a pivot, he throws all his weight forward on his hands, at the same time squeezing the waist between them as if "to force everything in the chest upward out of the mouth." Then he lets go suddenly with a final push that sends him back to the first kneeling position.

Then he rests a few seconds and repeats the procedure, at first making four or five movements to the minute, and then as many as fifteen. Though this method accomplishes much

Fig. 325.—Sylvester's Method (Second Position). Patient's arms pressed against the sides of the chest, to expel the air.

more than its predecessor, it requires two operators, and it may be a question whether the kind of "squeezing" that is spoken of be an altogether safe procedure. An objection has been made on several occasions against the pulling forward of the tongue (Howard) on the ground that it does not open the larynx, by pulling the epiglottis forward. Practically speaking, however, it will be found of great use, for even if it does not move the epiglottis, it flattens the tongue and thereby materially facilitates the ingress and egress of air. Often it will be noticed, especially in narcosis from ether, that the tongue will settle back in the cavity of the mouth, so that little or no air can enter the larynx except through the nostrils. After the tongue has been seized by the forceps and drawn out, natural breathing will be in a great measure restored.

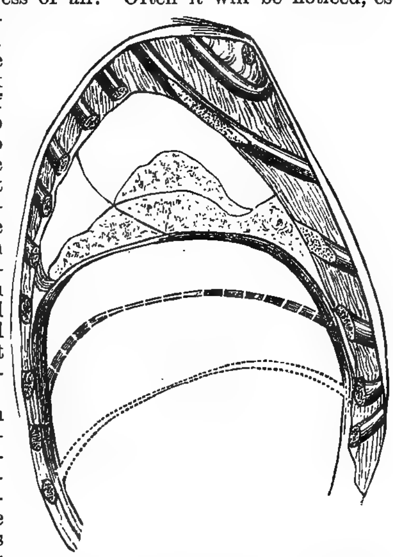


Fig. 326.—This figure indicates how the lungs are compressed by the action of the diaphragm. The lower curved and punctate line represents the diaphragm in a state of active contraction; the middle curved line shows how it appears during moderate contraction; the upper curved line demonstrates how far upward the diaphragm may extend in complete relaxation. Toward this upper limit the diaphragm can be forced by the hand pressure advocated in this method of resuscitating the drowned. (After Rosenthal.)

The Michigan method resembles the preceding in many respects. The individual to be resuscitated is turned on his face, and then the operator gets astride of the body. The clothing over the shoulders is seized in both hands, or (if the body be uncovered), the hands are placed in the arm-pits, and the shoulders are raised as high as they can go, without the head leaving the floor. This position is maintained while the operator counts one, two, three. Then the body is allowed to return to the ground. Next, without changing the position of his feet, he carries his elbows inside of his knees and places his hands on the lower ribs. Then he presses downward and inward with a force that gradually increases, while he counts *one, two*. Then he suddenly lets go and repeats

the first series of motions. These manœuvres should be continued ten or fifteen times a minute until natural breathing begins. This plan calls for but one operator, but it requires much muscular strength, especially if the person to be resuscitated be large and heavy, and the operator chance to be of delicate physique. Again, an important and necessary point is neglected. The tongue should be drawn out or depressed or some means be devised for letting the air pass in and out of the mouth easily, a point to which allusion has already been made.

A plan is now submitted that was first made public in 1878, and has been officially recommended for use along the coast line in one of our seaboard States. It has the merit of simplicity, calls for but one operator, though more may be advantageously employed, requires little muscular force, and subjects the individual for whom it is carried out to no danger. It is as follows:

1. If possible, try to get some warm and dry coverings in exchange for the wet clothing (send for hot water, or if it be not at hand have a fire built, into which bits of metal or stones may be thrown and heated, and where you may warm blankets or clothing of any kind, that may be applied to the drowned person). These matters should be attended to only when two or more assistants are available.

2. It is of very great importance to first get rid of the water that is in the body. To do this effectively roll the person over on the face, which should be a little lower than the body; if the bank be shelving let the heels be higher than the head (see Fig. 322); then wedge open the mouth and keep it open by a bit of wood, or by a knot in a handkerchief. The tongue should also be depressed. Then getting astride of the person press with the flat of the hand upon the abdomen, so as to push up the diaphragm. In half a minute, or probably less, the water will be driven out sufficiently to allow efforts at artificial respiration to be made.

3. Then turn the person onto the back, place him in a horizontal position, keeping the mouth wedged open as before, and the finger on the back of the tongue, and make pressure again with the hand upon the abdomen, so as to press the diaphragm upward (Fig. 323). Make the pressure slowly at first, and then force the air out. Then withdraw the hand, that the diaphragm may fall and the lungs inflate with air. This method permits the entrance of more air than when the chest-walls are compressed (see Fig. 326). At first make three or four movements in a minute, then increase to ten to fifteen, and persevere at that rate until there are evidences of returning respiration, or it is plain that life is extinct. If the operator is not alone, Sylvester's plan may be employed in addition. The arms are grasped at the elbows, and at each upward movement that is made with the hand upon the abdomen, the elbows should be carried downward, and pressed against the body; when the hand is withdrawn, the elbows should be raised and carried up alongside of the head. If others are at hand to assist, the body may be rubbed beneath the warm clothing, and ammonia may be occasionally applied to the nostrils. Some most extraordinary accounts have been published of resuscitation by the use of hot water externally, and this method therefore deserves a trial, in conjunction with, but not to the exclusion of, some one of the plans that have been recommended. In carrying out the hot-water plan, the clothes should be saturated with water, heated to 140° F., or as hot as the hand can bear.

When the pulse has been re-established, the patient should be removed to a quiet spot, and thin broths, beef-tea, or alcoholics cautiously given. The use of electricity has not been insisted upon, because it is of doubtful value. It should only be used in conjunction with other procedures, and when a reaction has been obtained the strength of the current should not be increased. One pole should be placed over the spine and the other over the præcordial region, if the heart is to be stimulated; if the diaphragm is to be stimulated, one pole should be placed over the pneumogastric, at the base of the neck, and the other in the seventh intercostal space of either side.

The period of suspended animation is a variable one, and some remarkable instances are on record. Thus, in the *Lancet* (1840–41, p. 607) a case is reported in which an infant was resuscitated in two hours, after ten minutes' submersion in two feet of water. In this instance the child was put into a bath at 75° F. and the water was gradually heated to 110° F. Friction and (probably most important) artificial respiration were made use of. In another case (*London Medical Gazette*, 1842–43, p. 448), a man had been immersed from twelve to fourteen minutes, but was finally resuscitated. The most remarkable case, however, that is a matter of scientific record, occurred at the French port of Oleron, in 1774 (*Annales d'Hygiène Publique*, vol. xliv., 1850, p. 306). It is narrated in the above journal that a lad of fifteen had been submerged for nearly an hour. He was rescued, rubbed, bled, and treated with laxative enemata, and recovered entirely, though not for several days. Though these accounts are so astonishing that they excite our incredulity, it should be remembered that animals may be deprived of air from eight to nine minutes (Woodman and Tidy) and then resuscitated. It is not impossible, therefore, that the human being may endure deprivation of air in a similar way and to even a greater degree. At any rate, unless an individual has been immersed for more than an hour, his life should not be utterly despaired of, and one or other of the above methods should be faithfully and systematically tried, until success crowns the effort, or it is plain that life is extinct.

Thomas E. Satterthwaite.

ASAFETIDA (*Asafœtida*, U. S. Ph., Br. Ph.; *Asafœtida*, Ph. G., Codex Med.). There is still some uncertainty about the exact source of this odorous gum-resin, although it has been long known to be the product of one or more large umbelliferous plants of Central and Eastern Asia. The plants have been seen growing, and the process

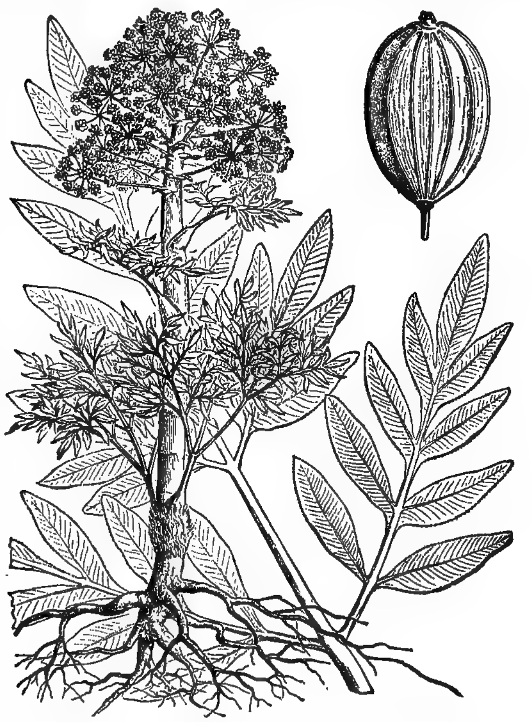


FIG. 327.—*Ferula Scorodosma*, Benth. and Hook., one of the plants yielding asafetida (Baillon).

of collecting and preparing the liquid juice has been carefully described by at least two European travellers, and others have brought home plants or seeds, which they believed to be the source of the drug, from the countries producing it, but an undeniable connection between these two sets of observations has not yet been traced. There is,

however, strong reason to believe that asafetida is, at least in part, derived from the following plants, while a probability exists that several plants furnish it.

1. *Ferula Narthex*, Boiss. (*Narthex Assafœtida* Falconer; *Peucedanum Narthex* H. Bn.), was discovered in West Thibet, near Kashmir, by Falconer, in 1838. It has since been cultivated in several botanical gardens, and has flowered in that of Edinburgh. It is an immense perennial herb, with a fleshy root, attaining a diameter of eight or ten centimetres (three or four inches), and with large, two- or three-times-divided leaves, arising from inflated sheaths and having lanceolate, linear, often wavy, serrated, decurrent leaflets. It does not blossom until it is several years old, when it sends up a stout, branched, flowering stem, two or more metres in height. The stem-leaves diminish rapidly in size, and after the first two or three, consist of little more than the conspicuous sheaths above mentioned, from the axes of which the branches of the inflorescence grow.

The flowers are in compound umbels on the ends of these branches, and altogether form a gigantic mixed panicle, reaching from near the base of the stem to its apex. The plant contains an abundance of milky juice, having a strong asafetida-like odor, and becoming yellowish-gray, and finally reddish and brown, upon exposure to the air.

2. *Ferula Scorodosma* Benth. and Hooker; *Ferula Asafœtida* Linn.; *Scorodosma fœtidum* Bunge: *Peucedanum Asafœtida* H. Bn., was discovered by Lehman in 1841, and has been seen by other Europeans in different parts of the great wastes and deserts around the Caspian and Aral seas. It is also to be found now in botanical gardens. Baillon considers it to be the plant which Kaempfer found yielding asafetida in Persia. Flückiger and Hanbury, however, regard this as "*not proven.*" It is, like the preceding, a very large perennial herb, with similar general characters, with thrice compound (primarily ternate, and then bipinnate) leaves; habit and inflorescence the same as the preceding, from which it differs principally by its very inconspicuous *vittæ* or oil-ducts, and in the less conspicuous, not inflated sheaths.

3. *Ferula alliacea* Boiss. (*Peucedanum alliaceum* H. Bn.), a Persian plant, exhaling a strong alliaceous odor. Baillon says that its seeds have always been included in parcels of seeds sent him from that country, as those of asafetida plants. It grows, but has not blossomed in European gardens.

The history of asafetida in Europe before the twelfth century is not clear, although it has been held to have been an article of commerce from near the beginning of the Christian era; but, from the twelfth century down, there is no doubt of its presence in European drug lists. On the other hand, of its use in Asia there is evidence in Arabian and Sanskrit writings of great antiquity.

The principal supply of this drug is collected in Afghanistan, and exported to India (Bombay), whence it comes to Europe or America. It is usually packed in large cases, but sometimes in bags or "mats." Asafetida, when the cases are first opened, is a moderately soft, yellowish-gray, rather tenaceous mass, of a not very homogeneous texture; sometimes lighter, whitish or yellowish tears are common in the mass; oftener coarse impurities are the cause of its unevenness. Upon exposure, this light-colored asafetida turns first pink, or reddish plum or violet pink, and then gradually becomes brown. Its odor is characteristic; strongly alliaceous, penetrating and persistent. It is exhaled, like that of onions, in the breath of persons taking it. Taste bitter and acrid, nauseous. When in lumps, even if long kept, asafetida is usually not quite brittle, but if finely broken and dried, it can be ground to powder, in the cold.

Our knowledge of the collection of asafetida rests principally upon the evidence of two travellers, who had the fortune to see it at an interval of nearly two hundred years from each other. The first of these was the celebrated Kaempfer, who observed it in the Persian province of Laristan. His description has been repeatedly quoted, and is, in the main, as follows: "About the middle of April, when the leaves have done growing, the fields are visited by the peasants, who dig away the ground around the older roots, tear off the leaves from the crown, and then carefully cover it up with earth and leaves, to protect it from the rays of the sun. After leaving the plant in this way for several weeks, they again uncover them, remove a portion of the top and cover them again, being careful that nothing touches the newly cut surface. In one or two days more the exuded juice is scraped off with a knife, a fresh surface is made by cutting off a thin slice, and the covering is repeated. This is continued until the root is exhausted, the product growing better as the season advances. The soft juice is mixed with earth to give it body."

The other authority is Staff-Surgeon Bellew, who saw asafetida collected during a visit to Afghanistan in 1857. The process was something like that observed by Kaempfer, but it was done at a season when the young leaves were sprouting, and instead of cutting off the top of the root they cut or gashed it in several places; the digging away the earth, and the covering of the roots to keep off the heat of the sun, were the same in both cases. Mr. Bellew states that the juice is mixed with gypsum or flour, although some very fine juice, obtained from the bud, is usually sold pure. This latter, like the fine juice of Kaempfer's later cuttings, probably never reaches the European markets.

The quality is considered fine according to the abundance of clear, whitish tears which it contains, and the absence of impurities and insoluble residue. Occasionally specimens are met with, consisting wholly of tears, but these are rare. The United States Pharmacopœia requires that it should dissolve at least to the extent of sixty per cent. in alcohol. The proportion of earth, gypsum, etc., named by Kaempfer and Bellew is not often seen in good medical grades, although they are apt to be dirty.

Asafetida consists, roughly, of oil, resin, and gum, but neither of these constituents is simple. The *oil* is present, according to Flückiger, to the extent of from six to nine per cent. "It is light yellow, has a repulsive, very pungent odor of asafetida, tastes at first mild and then irritating, but does not stimulate like oil of mustard when applied to the skin." It contains twenty or twenty-five per cent. of sulphur, and evolves sulphuretted hydrogen upon standing, and becomes acid upon exposure to the air. Specific gravity, 0.951: solubility; water, $\frac{1}{2000}$; alcohol and ether free. By (destructive) distillation at a high temperature it yields a beautiful blue oil (*ibid.*).

The *resin* is variable in quantity, but usually amounts to more than fifty per cent. (50, Hager; 71.4, Flückiger). It contains a small amount of crystallizable ferulaic acid and a large proportion of amorphous resin, yielding resorcin by treatment with potash, and blue and green oils, and umbelliferone by destructive distillation.

The *mucilaginous matter* is partly soluble, but principally of a kind insoluble in water. Impurities and ash variable; should not amount to more than ten to fifteen per cent.

Asafetida has no very marked physiological action, and does not appear to be poisonous in any dose, or to produce any more pressing symptoms than offensive flatus, eructations, perspirations, and urine (due to the elimination of its sulphur distention), and burning in the stomach, diarrhœa, dizziness, etc. In medical doses it is slightly laxative, decidedly carminative and antispasmodic, to a moderate degree tonic. It is a useful ingredient of "digestive" and "after-dinner" pills, in cases of slow digestion accompanied with flatus and constipation. It is, however, in the quieting effect that it has over the emotional "convulsive" colic-like and other dramatic functional disturbances of hysteria that the principal value of asafetida lies. In these cases it is almost always beneficial, and especially so when the above-named digestive derangements are also present. In chronic bronchitis, whooping-cough, asthma, etc., its value is less. It is not a hypnotic, but sometimes, by allaying irritability and so-called "nervousness," it often allows sleep to follow; for ordinary colic it does not compare with morphine or ether.

Asafetida is a rather popular veterinary remedy. It is also used as a relish, and the young leaves on one of the

above-described *Ferulæ* is used as a pot-herb in Asia by some of the Indians. Certain animals are also very fond of it.

Administration.—It may be given in substance by rolling the softish mass into extemporaneous pills and covering with gelatin, or by enclosing it in the common gelatine capsules, or "cachets de pain." Dose from one-half to one gram (0.5 to 1 Gm. = gr. viij. ad xvj.); or the officinal pills of asafetida (*Pilulæ Asafœtidæ*, U. S. Ph.), consisting of three grains of asafetida and one of soap, may be used. Dose, two to four pills, or, if given several times a day, one or two. For the prompt and certain action of single doses, however, a liquid preparation is better. The asafetida mixture (*Mistura Asafœtidæ*, U. S. Ph.), made with water, strength $\frac{4}{100}$, is the best, but it does not keep long. It may be given either by mouth or rectum (in either case the moral effect is considerable). Dose, by mouth, from ten to twenty grams (10 to 20 Gm. = ʒ ijss. ad ʒ v.); by the rectum, four or five times as much, diluted with hot water. The tincture (*Tinctura Asafœtidæ*, U. S. Ph.), strength $\frac{1}{5}$, is seldom given, but is used in making the mixture of magnesia and asafetida (*Mistura Magnesiæ et Asafœtidæ*, U. S. Ph.), which contains laudanum as its principal ingredient (see Opium). Asafetida Plaster (*Emplastrum Asafœtidæ*, U. S. Ph.:—Asafetida, 35; Lead Plaster, 35; Galbanum, 15; Yellow Wax, 15; alcohol), and Compound Pills of Galbanum (*Pilulæ Galbani Compositæ*, U. S. Ph.:—Galbanum, Myrrh, of each one and a half grain; of Asafetida, half a grain; syrup), are of limited usefulness. For the Pills of Aloes and Asafetida (*Pilulæ Aloes et Asafœtidæ*, U. S. Ph.:—Aloes and Asafetida, of each one and one-third grain; of soap the same) the asafetida is a useful corrigent to the aloes. Useful in chronic constipation.

Allied Plants.—The genus *Ferula*, as limited by Bentham and Hooker, comprises sixty species of Old World *Umbellifers*, of which about a dozen are reputed sources of mostly long-used gum-resins; besides those mentioned at the beginning of this article, the most important are:

Ferula galbaniflora Boiss. et Buhse.
Ferula rubricaulis Boiss. and perhaps others.................... } Furnish Galbanum.
Ferula Sumbul Hook fil................Yields Sumbul.
Ferula tingitana Linn..............African Ammoniac.

Closely related to this genus are:

Dorema Ammoniacum Don....
Dorema Aucheri Boiss........ } Sources of Ammoniac.

Also:

Peucedanum graveolens Hirn ....Dill.
Peucedanum sativum..........................Parsnip.

All the above are included by Baillon in the large genus *Peucedanum*.

For a notice of the order, see Anise.

Allied Drugs.—Asafetida and valerian are often mentioned together as duplicate medicines, but the latter has not the soothing carminative action of the former; as a simple antispasmodic it is fully as good. Musk resembles asafetida rather more than valerian. Ambergris belongs in the same list, but both are much inferior, and excessively costly; castor is cheaper, but still poorer and more offensive.

All these animal secretions are disgusting in their origin, and should be dropped from medical practice; largely diluted, their odor is not disagreeable. The essential oils and drugs containing them have in general some of the qualities of asafetida, and are frequently used for the same purposes. Camphor, the chamomiles, many mints, hops, as well as the bromides and other nervous sedatives, are instances. *Sagapenum* and *opopanax* are allied obsolete gum-resins, probably obtained from nearly related plants; their sources are not known. Plants in the genus *Allium* (onion, garlic, leek, etc.), and of the order *Cruciferæ* (mustard, horseradish, radish, etc.), furnish sulphuretted oils.

Other resins in this order, by destructive distillation, and German chamomile, by simple distillation, yield blue oils.

For other gum-resins, see Myrrh. *W. P. Bolles.*

ASARABACCA (*Asarum* ou *Corbaret*, Codex Med.). *Asarum Europæum* Linn.; Order, *Aristolochiaceæ*, is very similar to our Canada snakeroot, *Asarum canadensis* Linn. It is a small, stemless perennial, with a creeping, scaly root-stock, from which arise two long-petioled kidney-shaped leaves, with a solitary short-stemmed, purplish-brown, nodding flower. It grows in woods and shady places, especially under hazel bushes, in many parts of Europe, Siberia, and Central Asia; and has long been used in these places as a stomachic and emetic. It is still said to be esteemed in Russia, although dropped from modern medical practice in the rest of Europe.

The dried rhizome is usually once forked, irregularly bent and knotted, sparsely scaly, and of a grayish-brown color. It is obscurely four-sided, and bears numerous fine rootlets beneath. The leaves and flower are usually attached, although less valuable than the subterranean portion. The bark is thick and woody, cylinder small, the parenchyme loaded with starch. Oil-drops are also visible under the microscope in the pith and bark. The taste is bitter, nauseating, and peppery. The principal constituents are an *essential oil* and a crystalline camphor, *asarin*, which is said to be emetic. The above substances dissolve sparingly in water, but freely in alcohol, oils, etc.

In small doses asarabacca is stomachic and tonic, and has been considered good for the dyspepsia following alcoholic excess; in large doses it is emetic and purgative; by boiling, the emetic property, *asarin*, is said to be dissipated and the cathartic to remain. Dose, as an emetic, one to two grammes; as a stomachic, one or two decigrammes (gr. jss. to gr. iij.).

Allied Plants. — *Aristolochiaceæ* is a small order with no near affinities and little medical interest (see Snakeroot).

Allied Drugs.—For emetics, see Ipecac; for spices, see Pepper. *W. P. Bolles.*

ASCITES. The full term is Hydrops Ascites, but the latter word is commonly used alone. Synonym, Hydroperitoneum. (Ascites, from Greek, ἀσκίτης, from ἀσκὸς, a bag; French, *Ascite, Hydropéritonie;* German, *Bauchwassersucht, Ascites.*) By the term ascites is meant the collection of a thin fluid in the peritoneal cavity, not associated, however, with any inflammatory process in the peritoneum. It is a dropsy, and may occur either alone or in combination with dropsy of the pericardium and pleura and œdema of the subcutaneous connective-tissue.

The general causes of dropsy are like those of œdema, and have been considered in connection with anasarca, to which the reader is referred.

Ascites, when associated with dropsy of the other serous cavities and œdema of the skin, is dependent either upon obstructive valvular disease of the heart or disease of the lungs hindering the free passage of blood through them, thus giving rise to venous engorgement, and so to a transudation of fluid into the peritoneal cavity; or else it is dependent upon chronic diffuse nephritis, which leads to hydræmia. In the latter case, however, it may be said that the dropsy of the serous cavities is usually much less marked than is the anasarca.

Far more frequently the ascites is due to local circulatory disturbances, either in blood- or lymph-vessels, within the abdominal cavity. Thus in chronic interstitial hepatitis (so-called cirrhosis) the abundant growth of connective-tissue around the branches of the portal vein within the liver compresses these to such an extent as to lead to a venous engorgement of the radicals of the portal vein, and thus to a transudation of fluid. Again, tumors within the liver may cause a like obstruction, or a tumor may be so situated at the porta hepatis as to partially compress the main trunk of the portal vein, with a like result. Further, it is not uncommon to have an ascites in cases of malignant new-growths of the peritoneum, the probable explanation being that the tumors interfere with the absorption by the lymphatics of the fluid normally transuded from the blood-vessels.

The fluid in ascites is thin, clear, colorless, or else of a pale yellow tint, of a specific gravity varying from 1.010 to 1.020, containing considerable albumen, though always

less than the blood-serum. It frequently coagulates on exposure to the air, forming a jelly-like mass. Microscopically one finds a few endothelial cells, a few leucocytes, and sometimes a few fatty granular cells, which are probably fatty degenerated endothelial cells. Occasionally, in long-standing ascites, the fluid may be slightly cloudy from the presence of such fatty cells. Fibrin, when present, presents the characteristic microscopic appearances. It is, of course, understood, that coagulation, when it occurs, is dependent upon the formation of fibrin. In rare cases the fluid has a milky opacity, and when examined with even the highest powers of the microscope, one can make out the presence only of innumerable fine granules. Chemically it can be shown that these are fat. Their presence is doubtless due to a rupture of absorbent lymph-vessels of the intestinal tract or its neighborhood. To this form the name of chylous ascites (ascites chylosa) has been given.

The anatomical changes in the peritoneum in cases of ascites are often very slight. Frequently nothing more than a slight œdematous condition of the serous and subserous layers is to be seen. Sometimes the peritoneum, especially in ascites of long standing, becomes thickened and opaque, with here and there small papillary excrescences of connective-tissue.

Occasionally, by adhesion of opposing peritoneal surfaces, a sac containing fluid may be formed, which is thus shut off from the rest of the peritoneal cavity. To this condition the name of saccular or encapsulated ascites has been given.

If the fluid of ascites be bloody, the chances are strongly in favor of the existence of cancer or tuberculosis of the peritoneum.

The points in the diagnosis of ascites are the uniform enlargement of the abdomen, proportionate to the amount of fluid, and, when the effusion is abundant, the hernial protrusion of the umbilicus; the flatness on percussion, with change of level of flatness in varying positions of the patient; the impulse or wave transmitted from one side to the other when the abdomen is gently tapped; finally the finding, on puncture, of a fluid presenting characteristics like those described above.

Ascites, when associated with anasarca and a very pale skin, is in most cases dependent upon chronic diffuse nephritis; associated with anasarca, and a dusky or cyanosed skin, it is more likely to be the result of obstructive disease of the heart or lungs. Occurring alone, that is without dropsy of the other serous cavities or anasarca, it is dependent upon one or the other of the local causes previously mentioned, a differential diagnosis between which is hardly in place here. In certain of the cases of local origin an extensive dilatation of the superficial veins of the abdomen occurs, forming the so-called caput Medusæ.

Ascites calls for treatment only when the amount of fluid is so large as to press upon the diaphragm, thus interfering with its movements and embarrassing respiration. The object of treatment is, then, the removal of the fluid. If the ascites be complicated with anasarca, the treatment given in detail in the article Anasarca should be employed. It is, however, in the localized form that the fluid is present in the greatest quantity, and in these cases general experience has taught that diaphoretics, diuretics, and hydragogue cathartics have but little effect. Resort must therefore be had to tapping, either by the trocar and canula, or by the aspirator, and the whole or greater part of the fluid drawn off. As a rule the fluid rapidly collects again after such removal, and repeated tappings are often required.

Death is the common result in cases of ascites.

W. W. Gannett.

ASH, EUROPEAN (*Frêne*, Codex Med.); *Fraxinus excelsior* Linn.; Order, *Oleaceæ, Fraxineæ.* Tree, a good deal like our own ash, and having, probably, similar qualities. Both the bark and leaves have been employed in medicine, and appear to have somewhat different properties. The pinnate leaves contain *malic acid* and salts, *tannic acid, mannit, inosit,* and *glucose,* but nothing of physiological significance. They have some reputation in the treatment of gout and rheumatism. The bark is bitter, and contains the glucoside *fraxin.* It has been used as a tonic and antiperiodic, but ranks very low as either. *Fraxin* forms fine, shining, nearly white, four-sided prisms, of bitter taste. It is scarcely soluble in cold, but dissolves easily in boiling water. Its solutions have a blue fluorescence.

The leaves may be given in infusion to the extent of thirty grammes a day.

Allied Plants.—*Fraxinus Americana* L., the American ash, has probably similar qualities. *F. ornus* and others also contain *Fraxin.* For an enumeration of the Oleaceæ, see Olive Oil.

Allied Drugs.—The medicinal properties are too indefinite for close comparison. Besides the ashes, a number of trees in the order *Sapindaceæ* contain *Fraxin.* For a list of bitter glucosides, see Salicin. *Rhus glabra* L., contains abundance of malic acid and compounds, as well as tannic acid.

W. P. Bolles.

ASH, PRICKLY (*Xanthoxylum*, U. S. Ph.). Although commonly called by the above title, the trees producing this drug have no relation to the true ash, as they neither belong to the same genus nor order. There is a superficial resemblance, however, when they are in blossom. Prickly ash bark is furnished by two species of *Zanthoxylum* (or *Xanthoxylum*) growing in the United States; *Z. fraxineum* Willd., and *Z. carolinianum* Lambert; Order, *Rutaceæ* (*Zanthoxyleæ*). They are shrubs, or small, graceful trees, with slender branches and pinnate leaves. The flowers are polygamo-diœcious, small, greenish, and clustered in close cymes, near the ends of the branches. The greenish-red fruits have from two to five separate, one-seeded, dehiscent carpels. All parts of the tree are moderately fragrant and bitter, the fruit and leaves more fragrant than the bark.

The description of the dried bark, given by the Pharmacopœia, is as follows: "*Xanthoxylum fraxineum* is in curved or quilled fragments, about one-twenty-fifth of an inch (1 millimeter) thick; outer surface brownish-gray, with whitish patches, and minute, black dots, faintly furrowed, with some brown, glossy, straight, two-edged spines, linear at the base, and about a quarter of an inch (6 millimeters) long; inner surface whitish, smooth; fracture short, non-fibrous, green in the outer, and yellowish in the inner layer; inodorous; bitterish, very pungent.

"*Xanthoxylum carolinianum* resembles the preceding, but is about one-twelfth of an inch (2 millimeters) thick, and is marked by many conical, corky projections, sometimes four-fifths of an inch (2 centimeters) high, and by stout, brown spines, rising from a corky base."

The analyses of prickly ash bark have been somewhat confusing. It appears to have a little *essential oil,* but not much, and some *resin.* Witte, quoted by Huseman, found in the bark of *Z. fraxineum* a colorless neutral crystalline substance, which he has named *Zanthoxylloin.* It is insoluble in water, but freely so in ether and boiling alcohol; moderately so (one-eighth) in cold alcohol. In *Z. carolinianum,* G. H. Cotton found *oil,* a *crystallizable resin,* and a doubtful *yellow alkaloid.* The U. S. Dispensatory suggests the presence of *berberine* as probable. Probably some of the differences in various analyses have been due to not discriminating between the barks of the two species.

The use of Xanthoxylon has been entirely empirical, and but little idea of its qualities can be formed from the diseases for which it has been given. It is reported to be diuretic, diaphoretic, etc., but its chief reputation has been in the treatment of chronic rheumatism, for which it has been compared to guaiac. That it produces heat and warmth in the stomach is a natural result of its spiciness; to this quality it owes, too, its popular use as a counter-irritant in toothache, for which it may be compared to oil-of-cloves or pellitory.

Dose, from half a gram to two grams (gr. vij. ad gr. xxx.). A fluid extract (*Extractum Xanthoxyli*) is officinal, strength $\frac{1}{1}$; dose, same as above.

Allied Plants.—The genus *Zanthoxylum* (*Xanthoxylum*) comprises about eighty species of shrubs or trees,

inhabiting the warmer parts of the earth, and gives its name to one of the tribes of *Rutaceæ*. Most of them are spicy and bitter shrubs or trees. A number of South American and Asiatic species are used in the places where they grow as tonics and antiperiodics, while others, more aromatic and less bitter, furnish spices. "Japanese pepper," so called, is the fruit of *Zanthoxylum piperitum* D.C., and other Chinese and Indian species. It contains an essential oil, and a spicy-tasting volatile crystalline substance (stearoptene?) called *Zanthroxylin*. Some species are cultivated as ornamental trees.

Pilocarpus (Jaborandi) belongs to the same group. For a notice of the order, see RUE.

ALLIED DRUGS.—The medical character of the *Zanthoxyla* is of the stimulant, tonic type, like Angustura, Cascarilla, Magnolia, and numerous others. (See MAGNOLIA.) In its usefulness in rheumatism it has been compared to Guiac. For a list of spices, see PEPPER.

W. P. Bolles.

ASHBY-DE-LA-ZOUCH, a city in Leicestershire, England, in close proximity to the mines of this region, noted for its single saline spring and numerous baths. These baths, called the Ivanhoe baths, are frequented by rheumatic patients chiefly. The water contains a considerable proportion of bromine. Total solids per 1,000 parts, 66.0.

H. F.

ASHEVILLE. The town of Asheville, North Carolina, is situated in Buncombe County, one of the extreme western counties of that State, lying on an elevated plateau which is hemmed in by the Blue Ridge Mountains on the east, and by the Great Smoky Mountains on the west. Transverse ridges, extending as offshoots of these two great chains of mountains, intersect this plateau at frequent intervals, forming a perfect network of lofty ranges which, taken together, constitute the southern extremity of the Appalachian system of Eastern North America. So packed and massed together are the mountains at this lower end of the Appalachian system, that their arrangement has not inaptly been compared to a coil in the description of this system which is given in the "Encyclopædia Britannica." Here, too, are to be found the loftiest peaks of the whole system, which seem, as it were, to crowd together and form their rallying-point at the southern extremity of the line. Mount Mitchell, or the Black Dome, is the highest of all these peaks, its summit rising to an elevation of 6,707 feet above the sea-level; 419 feet higher than the top of its rival, Mount Washington, in New Hampshire, near the northern extremity of the Appalachian system, and higher than any point of the North American continent east of the Rocky Mountains. No less than eight other peaks are specified by the writer in the "Encyclopædia Britannica" as also exceeding Mount Washington in height, and fifty-one mountains attaining an elevation of over 6,000 feet are mentioned by Professor A. Guyot, of Princeton College, as existing in the various chains and cross-chains of this wonderfully hilly country. The great plateau above alluded to contains within its limits fifteen other counties of Western North Carolina besides the county of Buncombe, in which Asheville lies, and of which it is the principal town; the lines dividing these sixteen counties one from another being determined either by the direction of the cross-ranges of mountains intersecting the plateau, or by the rivers which take their rise in these mountains. In extent the plateau is some one hundred and seventy-five miles long, and from ten or fifteen to fifty miles wide. Its average elevation above the sea-level is about two thousand feet, although parts of it, considerably to the north of Asheville, lie higher by some one thousand to fifteen hundred feet. Asheville itself has an elevation of 2,250 feet, and stands 250 feet above the waters of the Swannanoa River, near the junction of which with the French Broad River (in Lat. 33° 27′ N., Long. 82° 29′ W.) the town is built. According to the statistics of the United States Census for 1880, the population of Asheville township was 5,568; that of the town itself, 2,616.

While surrounded on all sides by mountain ranges, Asheville is, nevertheless, not shut in by them, the distance of the town from any of the more lofty ranges and peaks being at least ten miles in every direction. This point is of no small importance in considering the location of the town from a sanitary point of view, inasmuch as it insures to it an abundance of sunshine at all hours of the day—which, together with the absence of the "down-draughts" of cold night-air characteristic of places lying in a deep and narrow valley at the foot of overhanging slopes, contributes not a little toward the production of the comparative equability of temperature and comparative dryness of atmosphere which characterize the Asheville climate. At the same time it must not be supposed that the location of the town is upon a monotonously level table-land. Such a "table-land" configuration of the earth's surface does not exist throughout the whole region of Western North Carolina; for the floor of its great plateau is broken and intersected by the secondary foothills, outlying spurs and buttresses of its bounding and transverse mountain chains, in such manner that the whole surface of the country could not well be less level or more broken and uneven than it is.

Excepting, of course, the immediate vicinity of its larger towns, or rather villages, the whole of this region is covered with a dense growth of primitive forest, the trees (chiefly of the deciduous variety), climbing almost to the very summits of the loftiest mountains. Streams of clear mountain water abound in every direction, and unite to form rivers of considerable size, many of which (as notably the French Broad and the Swannanoa) are justly celebrated for their exceptional beauty.

But, without stopping to mention the points of special interest and beauty which are to be found in this extensive and wild mountain region (the detailed consideration of which belongs rather to a guide-book than to a work of the present kind), we shall merely sum up our general description of the region by remarking that without doubt it constitutes one of the most beautiful and picturesque tracts of land—if not the most beautiful and the most picturesque—to be found within the whole territory of the United States, east of the Rocky Mountains.

For many years past, Asheville and the whole country about it have been a favorite summer resort for the wealthier inhabitants of the Southern States. To the same class of persons at the North, it was formerly but little known; a fact to be attributed chiefly to the remoteness of the region from the winter homes of the latter, to its inaccessibility, and to the very indifferent accommodations afforded by its rather primitive hotels. From the last-mentioned inconvenience the Southern gentry would suffer much less than their Northern brethren, as many of the former had villas of their own scattered through the mountains, and were, in consequence, comparatively independent of the hotels. The recent penetration of the country by several lines of railway will, no doubt, render the region better known to Northern visitors and will tend to vast improvement in, and extension of, its hotel accommodations. Over and above the desirability of Asheville and its surroundings, as a place of refuge for sufferers from hay fever, and for other persons desirous of escaping from city air and from a lowland country during the hot months of the year, the town itself has of late attained a measure of well-deserved celebrity and popularity as a winter resort; more particularly for patients suffering from pulmonary phthisis. A "high-altitude" health resort for such patients Asheville certainly is not, as its elevation of only 2,250 feet precludes its being considered as belonging strictly within the category of such places. A "medium-altitude" resort it is; and, short of the often inconveniently distant Rocky Mountain Plateau of Colorado, New Mexico, and Arizona, no better elevated winter and summer resort for phthisical patients exists within the territory of the United States; probably none as good. In speaking thus of Asheville as a winter resort for cases of pulmonary phthisis, the writer would be understood as referring chiefly to the natural and climatic advantages of the place. Concerning the degree of comfort in the all-important matters of

food and lodging possessed by the hotels and boarding-houses now existing at Asheville and in its neighborhood, he is unable to speak from personal experience, and is not in possession of thoroughly full and reliable information on this point. During the existence at Asheville of the American Mountain Sanitarium for Consumption, there is good testimony to show that proper accommodation in these respects did exist. Before the establishment of this excellent institution, in June, 1875, it is certain that such essential facilities for the treatment of invalids did not exist. The removal to New York City of its founder and manager, Dr. W. J. Gleitsmann, caused the abandonment of this sanitarium in 1880.

That proper accommodations exist to-day in at least some of the hotels and boarding-houses, would seem to the writer to be a probable thing; but, as already stated, he has no definite knowledge upon this point, and would therefore beg to refer all readers to guide-books, and to the personal experience of friends, for precise information of this kind. During its limited term of existence the results obtained at the Sanitarium of Dr. Gleitsmann were certainly both encouraging and creditable to the institution; and it would seem most desirable that the project of re-establishing such an institution, modelled upon the pattern of the celebrated sanitaria and "Kurhaüser" of Europe, and under proper management (as was the establishment above referred to), should be renewed.*

Concerning the immunity from pulmonary phthisis enjoyed by native inhabitants of the Western North Carolina district, the following testimony is presented. In the pamphlet numbered (4) in the appended foot-note, Dr. Chaillé says (p. 6): "My direct evidence as a practising physician is limited to the neighborhood of the Warm Springs, on the French Broad River, and some nine hundred feet lower than Asheville; though often consulted by the resident population, I have never seen but one case of consumption—this in a mulattress, not a native of this section. My hearsay evidence is more extensive, yet I have never heard of but two other deaths by consumption in this neighborhood; these were of a young brother and sister, in whom the disease was said to be hereditary, and whose family had not been long resident in this region. I have made repeated mountain excursions in all directions from Asheville; everywhere I was assured of the comparative immunity from consumption of all this section, and in most places my informants denied that the native residents ever died of the disease."

Dr. Chaillé's testimony is of especial value because, as he tells us in this same pamphlet, he had passed from three to five months annually in this region during the four years, 1873, '75, '76, '77. In pamphlet numbered (1) in the foot-note, Dr. Gleitsmann tells us that "malaria and its consequences are unknown here (viz., at Asheville), and a recovery from its manifold sequelæ can safely be expected." As to the particular class of consumptives for whom a residence in this high-lying mountain region is especially to be recommended, the reader may be referred for more specific information to the articles on "Consumption, Climatic Relations of," and to the general articles on "Climate" and on "Health Resorts," etc., etc., to be found in this HANDBOOK. Those who will be likely to derive most benefit, or even a complete cure of their disease, from a sojourn in the mountains of North Carolina, will be such patients as show only commencing lesions of phthisis, and those whose strength will therefore admit of their taking an abundance of exercise in the open air; finally, those whose patience and perseverance will induce them to stay for the longest period of time consecutively in the pure and bracing air of the mountain country.

The two following tables, lettered respectively A and B, will be found to contain many useful and interesting

* For more detailed accounts of this institution and of the results therein attained in the treatment of patients, as well as for much interesting information concerning the climate, etc., of Asheville, the reader is referred to the following pamphlets: (1) "Western North Carolina as a Health Resort," by W. Gleitsmann, M.D., 1876. (2) "The Climatotherapy of, and the American Mountain Sanitarium for, Consumption," by Stanford E. Chaillé, A.M., M.D., 1876. (3) "Biennial Report of the Mountain Sanitarium for Pulmonary Diseases," 1877, by Dr. Gleitsmann. (4) "The American Mountain Sanitarium for Consumption at Asheville, N. C.," by Dr. Chaillé, 1878. All these four pamphlets were issued by the press of Sherwood & Co., Baltimore, Md., three of them being reprints of articles which had appeared in medical journals.

TABLE A.

Observations of Climate of Asheville, N. C., 2,250 *feet above sea-level, North Lat.* 35° 27′, *West Long.* 82° 29′, *for a period of from two to thirteen years, by Dr. J. W. Gleitsmann, New York.*

Observations.	Jan.	Feb.	Mch.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Remarks.
Mean Temperature	37.70	39.40	45.50	53.90	61.70	68.80	72.60	70.60	63.70	53.60	44.60	37.80	54.10	Observations of 13 years (1867–1879).
*Mean maximum temperature	44.27	46.08	60.68	64.60	73.27	78.72	84.54	79.71	73.72	66.93	54.25	44.74	64.30	Observations of 2 years (1878–1879).
*Mean minimum temperature.	27.64	29.92	39.53	44.78	50.51	57.97	65.55	63.29	54.55	51.05	36.12	30.79	45.98	
*Abso. maximum temperature	69.20	71.50	74.50	78.10	85.00	88.00	94.00	89.80	83.20	83.00	74.00	65.00	94.00	Observations of 4 years (1876–1879).
*Abso. minimum temperature	–6	14.00	12.00	23.00	32.00	45.00	53.00	50.00	35.50	21.00	13.00	4.50	–6	
Mean relative humidity	67.13	64.97	59.51	62.13	68.67	75.26	78.56	80.13	79.96	71.87	66.38	71.92	70.32	Observations of 4 years (1876–1879).
Average rainfall	2.62	3.69	4.30	3.43	3.50	4.21	4.88	4.62	2.32	3.05	2.90	3.03	42.55	Observations of 11 years (1869–1879).
No. of fair and clear days	17	16	25	20	29	23	21	20	22	25	23	18	259	Observations of 2 years (1878 and 1879).

* All maxima and minima temperatures were taken by self-registering instruments.

TABLE B.

Observations of Climate of Asheville, N. C., additional to such sent January 31, 1885, *by Dr. J. W. Gleitsmann.*

Range of Temperature.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	
Mean monthly	15.25	14.62	20.27	18.20	20.36	20.07	18.90	16.30	17.06	17.00	19.00	8.00	17.08	1878.
Absolute monthly	50.00	41.50	43.50	42.10	46.70	40.70	30.70	27.80	37.20	47.00	39.00	46.00	50.00	
Mean daily	15.31	14.62	19.58	18.16	20.35	20.17	18.50	16.23	16.91	*	*	*	....	
Absolute daily	26.50	30.00	33.50	31.20	35 60	36.00	24.70	26.10	28.00	*	*	*	....	
Mean monthly	18.01	17.69	22.04	21.45	25.03	21.43	19.27	16.54	21.28	14.76	17.26	19.99	19.56	1879.
Absolute monthly	68.80	50.50	45.20	53.50	53.00	43.00	41.00	36.00	44.50	51.00	58.20	54.00	68.30	
Mean daily	18.03	17.40	20.75	*	25.03	*	*	*	*	*	*	*	....	
Absolute daily	37.00	32.50	36.00	*	38.00	*	*	*	*	*	*	*	....	

* Calculations not made.

data of the Asheville climate. Table A was kindly sent to me on January 31, 1885, by Dr. Gleitsmann, in reply to a letter of inquiry addressed to him a short time previously. In his letter accompanying this table, Dr. Gleitsmann apologizes for the incompleteness of the data presented, explaining that, owing to his removal from Asheville to this city, and to the shortness of the interval allowed for preparation of the table, the figures necessary to render the latter fuller and more complete were not at his command.

The second table (lettered B) was sent me by Dr. Gleitsmann on February 15, 1885. For the incompleteness of this table also the doctor apologizes in his letter of the latter date. His full records having been left at Asheville, he was able to present only partial data for both tables; but, incomplete as these data are, they are, nevertheless, far less so than are the figures frequently to be found appended to articles on similar places of resort, and the figures of the second table in particular are most valuable as bearing testimony to the comparative equability of the Asheville climate. For the pains he has taken in the preparation of these charts, and for the loan of the four pamphlets already alluded to, as well as for other valuable information contained in his letters, written in reply to inquiries made by the writer of the present article, the latter desires to express his cordial thanks to Dr. Gleitsmann.

In the pamphlet numbered (3) in the foot-note of this article, the following statement is made by Dr. Gleitsmann: "The temperature in winter (at Asheville) rises during mid-day, with few exceptions, to 50°, and over, and in sheltered places, with southern exposure, where patients congregate, to 70° and 80° in the sun. The greater number of days in winter have clear and bright sunshine, and insolation being notoriously more powerful in the highlands than in the lowlands, makes out-door life all the more pleasant. The beauty of these bright, cloudless days, and their bracing and tonic influence on invalids, can only be realized by actual experience."

A table showing the diurnal range of temperature at Asheville during the two years, 1873 and 1874, and its comparison with the same climatic factor, as existing at several of the Rocky Mountain Signal Service Stations, will be found of interest to the reader. Two of the four Rocky Mountain stations are health resorts of considerable celebrity, and, as might be expected from its much lower elevation, and, in part, from its lower latitude, the diurnal range at Asheville is observed to be very considerably less than at either of those two places. The following statement is from a foot-note at the bottom of page 11 of the pamphlet numbered (2) in the foot-note accompanying this article:

"Mean temperature of spring, 53.49°; summer, 70.72°; autumn, 53.48°; winter, 37.87°."

These figures were taken from a summary of observations on the temperature and rainfall of Asheville, made by E. J. Aston, Esq., and covering a period of observation extending over eight years (1867–1875). The same foot-note goes on to say that Asheville, "situated at about 35° 30′ latitude, has the summer temperature of St. Paul, Minn., 45°, and the winter temperature of Fayetteville, Ark., 36° of latitude." Concerning the annual rainfall of Asheville, Dr. Gleitsmann remarks, in one of his pamphlets, that it is considerably less than that of the region of Western North Carolina, taken as a whole, and less than that of any other of the eighteen stations existing throughout the State, with the single exception of Greensboro. These figures for the rainfall are quoted by Dr. Gleitsmann from a report of Professor W. C. Kerr, State Geologist of North Carolina, which gives the result of several years of observations. With reference to the prevalence of snow in the neighborhood, the following statement is quoted from a pamphlet by the late Dr. H. P. Gatchell, of Asheville: "The snow seldom remains many days at a time, even on the highest mountains, and its stay in the valleys can generally be measured by hours."

The soil of Asheville is "mostly red clay, in some parts sand, but in spite of deep mud, at times, dries rapidly." (Letter from Dr. Gleitsmann, dated February 15, 1885.) "A year or so ago the town had water (free-stone) brought from the mountains, and pipes laid on the principal streets, which also are paved and provided with sidewalks" (*Ibid.*). In a subsequent letter from the doctor, in reply to an inquiry respecting the drainage of Asheville, he says: "I did not say anything about drainage, as there was none when I was there, and probably never will be an artificial one, the town and whole surrounding country being hilly." This absence of artificial drainage is what might be expected in a place of so few inhabitants as Asheville; and, in view of the fact that the supply of drinking-water comes through pipes and from a distance, such absence is of course much less to be regretted than it would be in case the water were derivable only from wells or from some neighboring streams. Finally, it is worthy of mention that schools exist at Asheville for the education of the children of such families as may desire to make the town a place of residence for any considerable length of time; that good hunting and fishing are to be found at points some ten or fifteen miles distant from the town; and that, as might be expected in such a region, many interesting excursions may be made to places, both distant and near, and lying in every direction about the town.

Many other points of great beauty exist throughout the whole mountain district of North Carolina, for accounts of which the reader must be referred to the guide-books of this region. Some of these places are, doubtless, quite as favorably situated for purposes of health-seeking, as well as for pleasure-seeking, as is Asheville itself; but their development under the former aspect is as yet in its infancy. An account of the Warm Springs of Western North Carolina will be found in its appropriate place in the HANDBOOK, and does not belong (as neither do references to other less widely known mineral springs of this region) in an article dealing exclusively with the purely climatic features of these mountain resorts. In conclusion, the following figures, deduced from the tables of the United States Census for 1880, may be of interest to the reader, tending as they do to support what has already elsewhere been claimed for the immunity from pulmonary phthisis enjoyed by native residents of the western part of this State.

In the Mortality Tables of the Tenth Census (1880), the whole State of North Carolina is divided into three groups of counties. Of these three groups, the last, or Group 3, contains the twenty-four counties lying among, or in close proximity to the great mountain chains already described; sixteen of these twenty-four counties are those lying actually within the limits of the great Appalachian plateau. The total population of these twenty-four counties in 1880 was 234,881; that of all the other counties of the State, taken collectively, was 1,164,869. The mortality from pulmonary phthisis occurring during the census year in the third or mountain group of counties was 251; or 10.6 for every 10,000 of population. Throughout the other counties of the State, having, as just stated, a total population of 1,164,869 souls, the mortality from pulmonary phthisis during the census year was 1,879; or, in other words, 16.1 for every 10,000 of population; a number not large in itself, but yet more than fifty per cent. larger than the corresponding figure for the higher-lying and more sparsely settled portion of the State comprised in the twenty-four counties constituting Group 3.

Huntington Richards.

ASKERN. A sulphurous spa near Doncaster, England, frequented since the beginning of the eighteenth century. Total solids, 3.376 in 1,000 parts, chiefly sulphates of magnesium and calcium, with chloride of sodium. The water used in the baths is diluted. The place is much frequented during the summer months. The indications for the use of Askern waters are rheumatism and skin affections. *H. F.*

ASPARAGUS (*Asperge*, Codex Med.). The common garden asparagus (*A. officinalis* Linn.); Order, *Liliaceæ*, will hardly be made more familiar by description. It is

a native of Europe, and cultivated everywhere. Both the underground portion and stems are official in France.

Asparagus Root, as it is generally, but not properly, called, consists of a fleshy, scaly, much-branched rhizome. The dried rhizome is as thick as the finger, somewhat compressed, tortuous, brown, with numerous scars of stems on the upper side, and yellowish-white fibrous roots below. Taste insipid, mucilaginous, sweetish; odor, none. It should be gathered in the autumn.

"Asparagas Root" contains *resin, glucose, dextrin,* bitter, extractive, and other simple constituents, but no *asparagin.* The fresh sprouts are also considered to be a medicine, and have, in addition to the simple substances mentioned as in the root, the interesting compound *asparagin,* discovered in 1805 by Vauquelin and Robiques.

As a medicine asparagus is of little use. Its property of modifying the odor of the urine is known to every one. It may increase the urine, but does not do so always. It appears to make it slightly irritating, and to prompt to more frequent micturition. In large doses it has been compared, in its effects upon the heart, to digitalis, but is never now used with this in mind. Pure asparagin does not appear to entirely represent asparagus, since the root is also used, which has none of the glucoside in it. Dose, indefinite. The French Codex gives a syrup, consisting of the fresh juice, 1,000 grams, and sugar, 1,800, the dose of which is from ten to twenty grams (ʒ ijss. ad ʒ v.) and a *tisane* (infusion) of the root, strength $\frac{1}{200}$.

Allied Plants.—Asparagus is the type genus of a tribe of Liliaceæ (*Asparagineæ*), whose most obvious characteristic is in having the leaves reduced to scales, while from their axils develop small filiform branches, taking the place of, and usually regarded as, leaves. The genus comprises one hundred species, chiefly European and Asiatic. One or two species of *Ruscus* have been used. For notice of *Liliaceæ* see Squill.

Allied Drugs.—See Couch Grass; for Asparagin see Marshmallow. *W. P. Bolles.*

ASPERMATISM is that condition in which sexual intercourse is not accompanied by an ejaculation of semen, either because that fluid does not enter the urethra, or because its expulsion is prevented by some obstacle in the urethra anterior to the prostate gland. (See Sterility in the Male.)

ASPHYXIA (α, privative, σφύξις, a pulse). Diminution or suspension of hæmatosis and of the respiratory function from some hindrance to the entrance of air into the lungs.

The term in its literal acceptation applied, in days gone by, to every state of apparent or real death in which there is a primitive absence of pulse and cessation of beating of the heart. Not knowing the composition of atmospheric air, and the chemical phenomena of respiration, the ancients were unacquainted with the theory of respiration as at present understood, and for a long time asphyxia had no other meaning than that of *pulselessness.* To the end of the last century this opinion is met with in the greater part of the old authors, who considered the heart as the promoter and great regulator of vital phenomena, and naturally attributed their suspension to arrest of its functions. Since the action of the heart continues in asphyxia after the cessation of all other vital phenomena, it is evident that the word asphyxia is an improper expression for a chemico-vital phenomenon in which the animal is said to be neither living nor dead.

To get a just idea of asphyxia the etymology of the word must be completely forgotten. Being now turned from its primitive sense it has, in medical technology, and even in common language, quite a different signification, experiments having shown that the physiological fact qualified summarily under the name of asphyxia, may be the consequence of several pathological states, or of distinct functional troubles. Broadly speaking, there will be asphyxia when any obstacle whatever hinders air from penetrating the pulmonary vesicles, or when the fluid that penetrates them is of any other nature than the medium in which the animal is destined to live. Consequently the name asphyxia is applied generically to all accidental conditions in which life is threatened by any interception whatever of the respiration.

Many writers, in objecting to the term, have advised its abolishment from medicine, and seemingly with good reason, since asphyxia may be confounded with apnœa, suffocation, syncope, shock, dyspnœa, and other disorders of respiration, and with suspended animation from various causes. On the other hand, it is argued that it is preferable to retain this name rather than coin a new one, which, in its turn, may be inadequate to explain phenomena that may subsequently be revealed by science. So the old name remains as one of those bad scientific expressions that ancient medicine has bequeathed to modern physiology, and under the title are grouped many accidents or diseases that have no other relations between themselves than a gradual lowering of the hæmatosis, of the pulse, of the temperature, and of sensibility and motion.

By analogy the term has been extended to the withered condition found in vegetable life, and we speak of flowers perishing by asphyxia. Such figurative expressions as intellectual asphyxia and political asphyxia, are hardly open to the scientific objections that obtain in a physiological sense.

To get a clear notion of asphyxia it is necessary to mention several conditions that resemble or complicate it, but do not constitute asphyxia. Apnœa is physiologically opposite to asphyxia, since the stoppage of respiration is owing to the saturation of the blood with oxygen. Poisoning by toxic vapors, the fumes of sulphuric acid, chloroform, mephitic gases in general, and more especially the gas produced by burning charcoal, do not occasion asphyxia, but a true poisoning, resembling narcotic poisoning, in which the oxygenation of the blood has no recognized part. Of the toxic gases, the disastrous inhalation of which is erroneously attributed to asphyxia, an exception must be made in favor of oxide of carbon. It is demonstrated that this gas acts by paralyzing the blood-globules, and by obstructing the gaseous exchanges of which they are the agents. Between poisoning by the inhalation of toxic vapors and asphyxia there is this capital difference: in the pretended asphyxias the hæmatosis continues, in real asphyxia hæmatosis ceases. Asphyxiation by lightning and by vacuum, being of no practical interest, cannot be touched upon; and the complex state in which phenomena analogous to asphyxia are thought to occur in the fœtus, from impeded circulation of the placenta, does not appear to call for special mention in connection with our subject. *Infantile asphyxia,* or the apparent death of the new-born, is a distinct morbid condition brought on by a cerebral congestion, or by a syncopal state, and will be studied elsewhere. The term *local asphyxia* is rather a bold innovation that has been applied to certain forms of symmetrical gangrene of the extremities, supposed to be caused by the privation of oxygen, but in reality owing to embolic arrest of circulation in the parts affected. *Secondary asphyxia* may occur after drowning, or other cause of asphyxia. The individual having recovered from the primary effects of the asphyxia, dies suddenly, without apparent cause, after a lapse of a few minutes or several days. Such cases are explained as the secondary results of the arrested interstitial nutrition that took place during the period while breathing was temporarily arrested.

Interruption or suspension of the respiratory phenomena may be influenced by diverse circumstances. It is a matter of common experience that nervous impulses from without act upon the respiratory centre in various ways. Cold water dashed on the skin affects the breathing, and of all the apsychical nerve-centres, the one that controls respiratory events is, perhaps, most frequently and deeply affected by the action of the will and the emotions. When pulmonary absorption ceases, that is to say, when oxygen is diminished, and carbon dioxide is stored up in the blood and in the tissues, the rhythm and character of the respiration become changed by the venous blood mixture affecting the inhibitory nerves of the heart and the medulla oblongata, labored respiration fol-

lows, and this, in turn, gives place to dyspnœa, which merges into asphyxia, and a fatal termination ensues unless some restorative event occurs.

Many of the modifications that occur in asphyxia have been noted in physiological experiments. The blood of an asphyxiated animal resists slow combustion and putrefaction; when the venous blood enters the deep tissues of the organs suppression of the urinary and other secretions follows; the glycogenic function of the liver is interfered with, and if the asphyxiation be sufficiently slow, the temperature is lowered. An excess of carbon dioxide in the blood excites powerful respiratory movements; while hyperoxygenation, or saturation of the blood, with oxygen, checks the respiratory movements. Hearts of frogs, plunged in carbon dioxide, stop beating in about ten minutes, but continue to contract during more than three hours in air, and at least an hour in nitrogen gas. Hearts of new-born rats placed in tepid water, saturated with carbon dioxide, and others in ordinary water of the same temperature, show that those placed in the carbonized water beat much quicker than the others. It is demonstrated that the contractile power of the heart is preserved much longer in oxygen than in carbon dioxide. There is also a loss of muscular contractility, notably in the muscles that control defecation and micturition, and in females near the full term of pregnancy the fœtus is expelled. The pupils, at first contracted then dilated to the maximum, offer in the fibres of the iris a phenomenon of the same order; the expansion in this instance being consequent upon the irritation of the centre in the medulla governing the action of the pupil. In the diminished respiration from deficiency of oxygen lies the true cause of dyspnœa and asphyxia. No animal can maintain the respiratory process in an atmosphere devoid of oxygen, or in one that does not contain, at least, ten per cent. of this gas, and such quadrupeds as whales, hippopotami, and seals, or the pygopodous birds would drown in the same manner as a dog if kept submerged long enough. It is mainly by virtue of the arterial plexus, known as the *rete miribilia*, which stores up a supplementary supply of oxygenated blood, that these animals are enabled to remain so long submerged and resist asphyxiation. Absence of the respiratory murmur in the chest, and abundance of mucous râles in the bronchi, always accompany asphyxia. Diminution of sensibility also comes on gradually, and following an ascending and centripetal march, appears last in the cornea. Progressive anæsthesia measures the degree of asphyxia, and absolute general insensibility indicates complete asphyxia. After all other movements have ceased the heart continues to beat, and finally stops in a state of diastole.

Asphyxia is one of the most frequent of the immediate causes of death. It may result from any of the causes that hinder respiration. These causes may arise from circumstances inherent to the individual, or they may be exterior to him. Asphyxia being brought about by the circulation of non-oxygenated blood in the lungs and the respiratory centre in the medulla oblongata, may be produced by any cause that tends to oxygen starvation, and the accumulation of carbon dioxide in the blood. Arrest of the thoracic movements and hindrance of hæmatosis may sometimes be produced by the thoracic spasms of epilepsy, tetanus, eclampsia, hydrophobia, convulsive asthma, the paralysis of the diaphragm, or of the thoracic walls in spinal or diphtheritic affections; by hæmorrhage at the base of the brain or in the medulla oblongata, or in poisoning by woorara, and by the slow and gradual feebleness which precedes and leads to death at the end of all diseases.

Mechanical obstacles to respiration often bring on cyanosis and anæsthesia, resulting in arrested hæmatosis. Special instances occur in the case of arrest of respiration by a foreign body in the larynx, or by a polypus, by œdema of the glottis, by an abscess of the pharynx or of the tonsils, by a goitre compressing the trachea, by an accumulation of mucus in the trachea in capillary bronchitis, by an extensive pneumonia, by a considerable hydrothorax, by strangulation, by intestinal pneumatosis compressing the diaphragm into the thoracic cavity, by pressure on the chest, not capable of being overcome by respiratory efforts, such as the falling in of earth, being crushed in a crowd, or by the accident of overlying that often happens to young children, and by changes in the pressure of the air breathed, no matter whether this be a gradual diminution, a sudden diminution, or an increase. Asphyxia may also result from traumatic cause, as injury to the spinal cord or the base of the brain; a double wound of the chest admitting air, an opening of the diaphragm permitting the passage of the abdominal organs into the thorax, and from hæmorrhage.

In the foregoing instances the air surrounding the individual does not present any alteration, the inspiratory efforts produce still some effect, but this effect is insufficient to preserve life.

Submersion in any liquid medium whatever causes asphyxia, and it may be caused by being surrounded by a medium devoid of oxygen and improper to support sufficient hæmatosis, as hydrogen, nitrogen, and the protoxide of nitrogen, gases not toxic, properly speaking, but considered irrespirable.

The three typical modes of asphyxia, the most important practically, and the best studied in theory, occur in strangulation, submersion, and confinement.

In occlusion of the air-passages from mechanical impediment, such as garotting, throttling, or by a noose or ligature, death results essentially from asphyxia. In some cases of hanging death may occur from asphyxia in combination with coma, the conjoint causes of occlusion of the air-passages and disturbance of the cerebral circulation giving rise to the condition known as neuro-paralysis. It is observed in a general manner that all kinds of death caused by the privation of respirable air have between themselves the greatest resemblance. Whatever be the obstacle that intercepts the connection of the lungs with the atmosphere, the apparent differences are only secondary, and the essential symptoms are identical, because all act in suppressing the functions of the blood and hæmatosis. In fact, the phenomena of asphyxia are constant, and related to disturbances in the respiration, innervation, and circulation, which vary according as the asphyxia is the result of submersion or of the absence of oxygen in the surrounding medium, according as it is immediate or slow. The fatal result of asphyxia is owing to the introductory arrest of the pulmonary circulation, the capillaries of the lungs being incapable of conveying venous blood. The stagnation of the blood in the lungs is followed by paresis of the respiratory centre and stoppage of the heart.

It is doubtful whether life be ever recalled in any case after stoppage of the heart following on asphyxia, yet the facts of suspended animation prevent the formulation of precise statements in this regard. Pigeons apparently dead from the effects of chloral hydrate recover, and fish frozen for a considerable time can be resuscitated by immersion in cold water. The writer has seen frozen terrapins resuscitated in the same manner.

Asphyxia, though not always the mode of death in those submerged, is commonly present in a certain number of cases. The resistance of new-born animals to this mode of asphyxiation is especially noted in the greater time required to drown a new-born pup than an adult dog. One minute and a half usually suffices to drown a dog, while a new-born pup often requires as much as fifty minutes. This great difference is owing to the less active change of tissues, and the smaller consumption of oxygen in the young animal. The more active the vital combustion, and the greater the demand upon the general store of oxygen in the blood, the quicker the young animal perishes when the respiration is obstructed.

Accidents owing to the absence of respirable air, or to confinement in places where the air is not renewed, are of common occurrence. Asphyxia from this cause is less prompt than that by strangulation. The phenomena connect and follow one another. Efforts to execute the respiratory function are soon followed by head troubles, with nausea, loss of consciousness, diminution of the pulse, and insensibility of the skin.

Although no warm-blooded animal can live in any medium not containing a sufficient mixture of oxygen, yet animals may become habituated to deteriorated air, and in certain conditions of suspended animation may live with impunity in a vacuum, and even in a medium charged with carbon dioxide. Rats and mice live in air containing but one, and even 0.5 per cent. of oxygen, and carnivora and birds resist death in an atmosphere where the proportion of oxygen will barely support the combustion of a candle. There is also a tendency in the new-born to resist asphyxia from confined air. Young sparrows without feathers have been known to live twenty-four hours in a space where the adult sparrow died in two hours. Marmots in a state of hibernation live under an exhausted receiver, but die when awakened. Cold-blooded animals resist longer the privation of atmospheric air, as can be fully seen in the case of frogs.

It is sufficiently demonstrated that death in confined air is, as death in nitrogen, by simple privation of oxygen. Death from asphyxia may also occur in atmospheres still rich in oxygen, but where the figure of carbon dioxide is too high, as in caves, cellars, and the like.

The important facts relating to the cadaveric lesion, the treatment, and the medico-legal questions likely to arise in connection with asphyxia will be found under other headings with their proper developments.

Irving C. Rosse.

ASPIRATION. In a paper presented to the French Academy of Medicine, November 2, 1869, Dr. Georges Dieulafoy brought to the notice of the profession a valuable method of detecting the presence of fluids in, as well as of removing them from, various parts of the body. The process is called Pneumatic Aspiration, or simply Aspiration. Briefly stated, it is a method of exploring diseased parts with a hollow needle, connected with a vacuum, or, as it is called by the inventor, a "previous vacuum."

INSTRUMENTS.—While several different patterns of aspirator have been devised and recommended, only two require notice here, as they comprise the principal advantages of each of the others.

The Dieulafoy Aspirator (Fig. 328*) consists of a glass syringe holding three or four ounces, and having two outlets at its lower end, each of which has a stop-cock, B B; a rubber tube, into which is let a glass index, E; and four needles of various sizes. The apparatus is used as follows: The needle having been connected with the syringe by means of the tube, and the outlets closed, the piston is withdrawn to its full extent, and secured by a quarter turn. The needle is now to be introduced at the proper place, and as soon as its point is buried in the tissues, the corresponding cock is to be opened, thereby extending the vacuum to the extremity of the instrument. The needle is carefully pushed forward as far as is desirable, or until fluid is found, which will be indicated by its appearance in the index, if not in the syringe. The latter may be emptied by closing its outlet leading to the tube, opening the other, and unlocking and driving the piston home. Another vacuum is to be made as before, and the process may be repeated indefinitely without removing the needle or disconnecting the syringe.

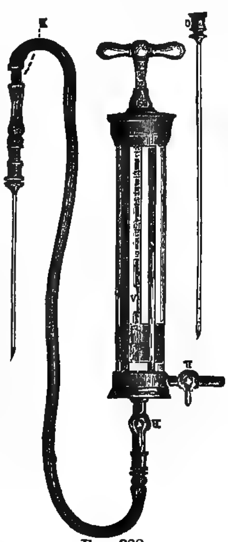


FIG. 328.

Should the needle become stopped up during the operation efforts may be made to clear it by reversing the action of the syringe, and forcing a little fluid back, or it may be partially withdrawn, or carried a little deeper, or its direction may be changed. These manœuvres failing, it must be taken out, cleared, and introduced in another place.

With this instrument, stimulating or other liquids may be injected into a cavity by filling the syringe with the fluid, instead of exhausting the air.

Potain's Aspirator (Fig. 329*) comprises an air-pump, *A*, having two openings, *C D*, each of which is supplied with a metallic valve, working in opposite directions, the former allowing an exit, and the latter an entrance, of air to the pump; a bottle, with a capacity of a pint or more, fitted with a rubber stopper, *B*, which is perforated by a double metallic tube, whose outer portion terminates in two branches, each having a stop-cock, *K L*; two rubber tubes, with the necessary needles, complete the apparatus.

It is made ready for use by connecting the bottle with the needle by the indexed tube, *E*, and with the pump by the tube, *G*. The cock, *K*, nearest the pump, is opened; the other is closed. The air is exhausted from the bottle by a few sharp strokes of the piston, and the cock, *K*, is closed. The puncture is now made, and as soon as the point of the needle is under the skin the corresponding

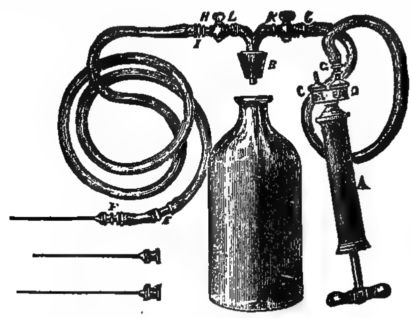


FIG. 329.

cock, *L*, is to be opened, and the exploration carried to completion. Another vacuum is readily established without disturbing the needle or its connections.

By attaching a rubber tube to the inner end of the metallic one, long enough to reach to the bottom of the bottle, and by changing the tube *G* from *D* to *C*, so as to force air into the bottle, instead of exhausting it, the apparatus may be used for injection or irrigation, or the bottle may be emptied of its contents by simply working the pump. This action is due to the fact that the inner orifice of the tube *K* is on the side just below the stopper, and hence independent of the tube in the bottle.

As a more perfect vacuum can be obtained with Dieulafoy's instrument, it is the best one for diagnostic purposes. It is also well suited for evacuating or injecting small quantities of fluid, especially when it is desirable to be exact as to the amount. But for drawing off large effusions, or for irrigating large cavities, Potain's apparatus saves time and labor. And it may be said that for general use the latter instrument is the more serviceable of the two, as it can be made to do the work satisfactorily in most of the cases requiring this operation.

The peculiar feature of the aspirator, which distinguishes it from the suction trocar, and which makes it so much more valuable, lies in what Dieulafoy calls the "previous vacuum." Extending to the point of the needle the operator is notified of the presence of fluid the instant it is reached, and therefore there is little danger of passing through a small collection of fluid without knowing it, or of wounding deeper structures unnecessarily, a matter of much importance in tapping joints and other cavities. The strong suction power of this instrument enables one to use smaller needles, as well as to evacuate fluids which are too thick to be withdrawn with an ordinary trocar.

* Leach & Green, Boston.

* Codman & Shurtleff, Boston.

The aspirator should always be tested just before it is used upon a patient, because, from its peculiar construction, it is very liable to get out of order. The piston gets loose, the needles are easily plugged with rust or dirt, the tubes crack and break, the cocks stick, the stopper may not fit the bottle. All of these points require attention in order to avoid embarrassment and delay.

It would be well if all aspirator needles were made after the pattern recommended by Dieulafoy, namely, Nos. 1, 2, 3, and 4, having the respective diameters of $\frac{1}{2}$, 1, $1\frac{1}{2}$, and 2 millimetres ($\frac{1}{50}$, $\frac{1}{25}$, $\frac{1}{18}$, $\frac{1}{12}$ inch). After having been used, the needles should be thoroughly cleansed with hot water (carbolized), dried, and threaded with a wire to keep them patent.

Small trocars can be used with the aspirator in place of the needles for purposes of evacuation and irrigation. For diagnostic explorations they are inferior to the needles, from the fact, that with the former it is impossible to make use of the previous vacuum. The trocars are of special value in tapping the chest, or any other cavity, in which there is danger of doing harm by the point of the needle.

In aspirating the cranium, pericardium, spina bifida, and intestine the smallest needle, No. 1, should be used. For the bladder, joints, strangulated hernia, and tumors No. 2 is suitable; while for abscesses, thoracic and peritoneal effusions, the larger sizes are appropriate.

Owing to the fineness of the needle, and to the elasticity of the tissues, almost any organ or part of the body may be safely explored with the aspirator. For example, the head, chest, stomach, liver, gall-bladder, spleen, intestines, uterus, tumors of various descriptions, and aneurisms have been punctured without untoward results. The principal diseases, however, in which the aspirator has been proved by experience to be of especial value are the following:

Retention of Urine.—In the severer stages of this affection aspiration, as a temporary resource, is often of great service. It is safe, speedy, and effectual. So little pain attends the operation, that, as a rule, anæsthetics are not required. If relief is not obtained in these cases from milder measures, together with a moderate trial of the catheter, it is far better to aspirate the bladder above the pubes than to irritate and perhaps lacerate the urethra by prolonged and often fruitless efforts at catheterization. The operation is best performed with Potain's apparatus. It being in readiness, the needle is entered on the median line just above the symphysis, and carried backwards and downwards toward the hollow of the sacrum, to such a depth that the point will not escape as the bladder contracts. When the viscus is nearly emptied the patient is apt to experience a pricking sensation, which is due to the needle's impinging on the posterior wall. It should be withdrawn a short distance, and the urine allowed to escape as long as it will without producing too much pain. The puncture in the skin may be covered with a bit of adhesive plaster. This operation can be safely repeated as often as may be necessary for two or three days, by which time the urethral irritation is generally so far subdued by appropriate measures that the power of voluntary micturition is restored, and the primary obstruction can receive the required attention.

Aspirating the bladder is preferable to the operation of tapping by the rectum, because it is safer, it is more easily performed, there is less liability to mistakes, and it is not followed by recto-vesical or other fistulæ, by extravasation of urine, or by pelvic or prostatic inflammation and suppuration, accidents which have occasionally supervened upon the rectal operation.

Affections of the Joints.—While almost any large joint containing a considerable quantity of fluid may be aspirated, the operation is chiefly confined to the knee. Large effusions in that articulation, whether of serum, blood, or pus, can be safely and quickly removed by this method. The needle is to be inserted wherever the swelling is most prominent, which is usually above or to the inside of the patella. Care should be taken not to wound the cartilages with the point of the instrument, as serious results have been known to ensue. After the operation the patient should be kept in bed, the limb should be placed upon a posterior splint, and firm pressure should be applied by means of flannel or rubber bandages. Should the fluid reaccumulate the operation may be safely repeated as often as is necessary. Anæsthetics are required only in children, and in nervous or timid subjects.

Strangulated Hernia.—It was thought at one time that aspiration might prove to be very beneficial in the treatment of this affection, but it has not stood the test of experience. The needle is apt to become clogged, or from various causes the tumor cannot be sufficiently reduced by this means to enable it to be returned to its proper place. It is true that many cases of successful reduction of the hernia after aspiration have been reported from time to time, but as the operation oftener fails than succeeds it is less frequently resorted to at present than it was formerly. Fatal results have followed this procedure, yet, when carefully performed with a No. 2 needle, it is attended with little danger, and it is occasionally successful.

Abscess.—Aspiration is frequently of the greatest value in determining the presence and character of fluids, but as a method of treating ordinary abscesses, it is far inferior to free incisions, drainage-tubes, and antiseptics. The pus usually reaccumulates after each evacuation, until finally a spontaneous opening takes place, unless it is anticipated by an artificial one. Occasionally, however, a favorable result follows repeated aspirations, as occurred in the case of an extensive pyæmic abscess over the sacrum, in the practice of a colleague. It was aspirated twenty-one times in twenty-five days, twenty ounces of pus being withdrawn at the first operation, and three ounces of serum at the last. But such cases are probably best treated by the method of incision, as above mentioned. An exception to this rule is an abscess occurring in a person, the subject of the hæmorrhagic diathesis. Such cases, when active interference is necessary, should be aspirated rather than incised, as the hæmorrhage would be less, and probably could be more easily controlled. Hepatic, perinephritic, and some other deep collections of pus may occasionally be treated by repeated aspirations. The diagnosis is thus rendered certain, the shock of the operation is less than that which follows incision, and in a certain proportion of cases a favorable result will be obtained.

Hæmatoma.—Collections of blood in the cellular tissue, resulting from contusion or other injury, may often be satisfactorily treated by aspiration, one or two operations being sufficient in many cases to effect a cure. A large needle or trocar may be used to evacuate the contents, and firm pressure should be applied to prevent a return of the affection. The withdrawal of effused blood by this method is much more successful than the evacuation of pus, and seldom does harm.

Pleuritic effusions can be readily drawn off with Potain's aspirator. It is better to use a trocar than a needle in these cases, as by so doing there is less danger of injuring the lung. The puncture may be made in the eighth or ninth intercostal space, about two inches below the angle of the scapula. The operation should cease the instant pain or coughing sets in, but it may be repeated as often as necessary. Should the fluid reaccumulate less rapidly after each evacuation, and the general health improve or at least remain good, a favorable result may be expected by persisting in the treatment.

It is the opinion of many who have had a large experience with this operation, that ether should seldom, if ever, be given during its performance. A number of fatalities have resulted from this practice. The pain is neither severe nor of long duration. Children may be restrained by moderate force, and adults seldom request an anæsthetic if the danger is explained to them. Should it be thought necessary to administer ether, a few whiffs, just enough to produce primary anæsthesia, is sufficient, and is much safer than complete etherization. But the rule should be, use no anæsthetics in tapping the chest.

The *pericardium* may be safely aspirated with the smallest needle, as follows: The puncture is to be made in the fourth intercostal space, about two and one-fourth inches (six centimetres) from the left border of the sternum,

and the instrument carried slowly backwards, upwards, and a little toward the median line. To avoid wounding the heart it is important that the vacuum should extend throughout the needle at the earliest moment possible. Little danger need be apprehended, even if that organ is touched with the needle. The latter should immediately be withdrawn under these circumstances, and introduced in another place. Aspirating the pericardium is an operation that will not often be required.

Should it be deemed advisable to evacuate the fluid in a case of *hydrocephalus*, it may be done with the smallest needle. The puncture should be made through the anterior fontanelle, far enough from the median line to avoid the longitudinal sinus. Experience gives slight encouragement for the performance of this operation.

Spina bifida has been cured by aspiration, either alone or followed by some stimulating injection. The smallest needle should be used, and pressure immediately applied.

Tumors may often be advantageously aspirated to determine their character or contents, but it is seldom that the operation is of any curative value. The most notable exception is probably that of a cyst of the broad ligament, cases of which have been cured by one aspiration.

Tympanites can be temporarily relieved by aspirating the intestines with a fine needle, but the method probably has no advantages over simple tapping, and, moreover, it is not entirely free from danger, as extravasation of fæces has followed and caused a fatal termination.

The principal dangers to be apprehended in performing aspiration are the wounding of large veins, arteries being seldom injured in this manner, extravasation of fæces and suppurative arthritis, as mentioned above, and peritonitis from tapping the abdomen. In conclusion it may be said that while aspiration is generally safe, yet, like every other operation, it should always be carefully performed, and with a full understanding of the possible accidents and results. *George W. Gay.*

ASSMANSHAUSEN, situated at one of the most beautiful points of the Rhine, possesses a thermal spring moderately impregnated with alkaline chlorides, but with a relatively large quantity of lithium bicarbonate. Its composition, in 1,000 parts, according to recent, but as yet unsatisfactory analysis, is: Sodium bicarbonate, 0.137; lithium bicarbonate, 0.0278; sodium chloride, 0.571. On account of the large proportion of lithium present in this water, it is adapted to and has been used with considerable success in cases of gout and vesical affections characterized by excess of uric acid sediment. It has also been proven to be useful in catarrhal affections of the respiratory, digestive, and urinary tracts. It is used both as a beverage and as a bath. *H. F.*

ASTHENOPIA (from ἀσθενής, weak, and ὤψ, eye) is the name proposed by Mackenzie (1843) to designate the complex of symptoms popularly called *weakness of sight*. "By asthenopia is understood that state of vision in which the eyes are unable to sustain continued exercise upon near objects, although the patient, upon first viewing such objects, generally sees them distinctly, can employ his sight for any length of time in viewing distant objects, and presents no external appearance of disease in his eyes. . . . In the open air the patient makes no complaint, being able to discern distant objects clearly and without fatigue. . . . In reading, sewing, and the like, he is obliged, partly from the confusion which seems to spread over the objects, partly from a feeling of fatigue in the eyes, to interrupt the exertion. . . . A very short period of rest is, in general, sufficient to recruit the sight, so that the power of perceiving small objects returns and the patient is in a condition to resume his employment. . . . When near objects fade away, as it were, from the asthenopic sight, some patients feel it a sufficient relief to turn their attention to remote objects, which they continue to see perfectly; others find remote objects also to appear confused, and require to shade their eyes till the attack wears off. The most complete relief is in all cases obtained by shutting the eyes. . . . Asthenopia is rarely observed to commence in those who have already reached the middle period of life, but almost exclusively takes its origin in childhood or youth. . . . Few patients, not even those who are mere children, continue to be long affected with asthenopia without making use of convex glasses. . . . A child, engaged in learning its lesson, complains that it cannot see, and repeats the complaint so frequently, especially by candle-light, that his father or grandfather at last says, 'Try my glasses.' The child now sees perfectly, and night after night the loan of the glasses is required before the task can be finished." To complete this graphic sketch, by Mackenzie, it is only necessary to add that the asthenope is able to see perfectly at a distance with the same convex glasses which make it easy for him to read, and that he only needs to wear convex glasses, of the shortest focus compatible with distinct vision at a distance, to be at once and completely relieved of his disability.

No allusion to asthenopia is to be found in the medical writings of antiquity. Taylor (1766) sketches its symptoms in a few lines under the name "debilitas visus." Scarpa (1801) mentions it as one of several forms of "incomplete amaurosis," and says of it that it is, "properly speaking, not so much an amaurosis as a weakness of sight from fatigue of the nerves, and especially of those which constitute the immediate organ of vision." Several later writers on the diseases of the eye have given excellent descriptions of asthenopia, but always in connection with amblyopia or amaurosis, of which it was assumed to be an early stage, and, therefore, a precursor of blindness. Gradually stress came to be laid upon fatigue as the essential symptom, but the seat of the fatigue was thought to be in the retina, and it was supposed that, if neglected, it might easily develop into amaurosis and end in loss of sight. Next it was shown that asthenopia, even of many years' duration, does not result in actual impairment of vision, and so it came to be classed as an amblyopia of a special and benignant type. Then the fact began to be recognized that the phenomena of asthenopia are essentially those of fatigue of the motor apparatus of the eyes, and the explanation was sought in weakness, or in over-tension of one or more of the external muscles of the eyeball. Still later, when the existence of a true accommodative adjustment had been generally conceded, asthenopia was thought to be dependent on weakness of this function, and was brought into connection with so-called presbyopic vision occurring in young persons. Finally, through the discovery of the mechanism of accommodation, and the demonstration of hypermetropia as an error of refraction, the way was opened for the recognition of the true cause of asthenopia in the overloading of the accommodation through the displacement of the region of accommodation in hypermetropia. Asthenopia is, therefore, not a disease, but a complex of symptoms dependent on an anomaly of construction. (See Hypermetropia.)

Hypermetropia may be briefly defined as a structural anomaly of the eye in which the refractive power is insufficient to focus parallel rays upon the retina without aid from the accommodation. In the highest grades of hypermetropia, the total accommodative power of the eye may be inadequate to meet the requirements of distinct vision, even at a distance, and the condition may then bear a superficial resemblance to amblyopia; but in the medium and lower grades there is ordinarily developed a state of habitual tension of the accommodation, under which the adjustment for the distance is easily and unconsciously performed, and only the greater exercise of the accommodation required for reading or other near work is felt to involve effort, and becomes wearisome. But the fatigue in accommodation for near objects is not solely the result of insufficiency of the accommodation for the work imposed upon it, for the normal position of the near point (p) in youthful hypermetropes is, in most cases, still well within the distance at which the book is usually held in reading, and it is also true that in hypermetropia complicated with strabismus, in which condi-

tion but one eye is in use at a time, reading and sewing are not ordinarily attended with especial difficulty, at least during childhood and youth. The principal determining cause of asthenopia is, in fact, to be sought in the close physiological relation which exists between the two correlated functions of accommodation and convergence, whereby any given degree of accommodation tends to evoke an equivalent degree of convergence, and, conversely, any given degree of convergence tends to evoke an equivalent degree, and no more, of accommodation. Hence, in hypermetropia, either the particular degree of accommodation required for distinct vision at any given short distance may be associated with convergence for a still shorter distance, and may thus predispose to convergent strabismus, or the degree of convergence necessary for binocular vision at the given distance may be associated with accommodation for some greater distance, and so may give rise to asthenopia.

Asthenopia may then be defined as the fatigue incident to a conflict between accommodation and convergence when divorced through the displacement of the region of accommodation in hypermetropia.

Although, strictly speaking, asthenopia is a misnomer, for it is not a result of weakness, nevertheless weakness (paresis) of accommodation may give rise to a train of symptoms not readily to be distinguished from true asthenopia. In paresis of accommodation following diphtheria, the simulation of asthenopia is perfect, but the absence of hypermetropia, the history of recent sore throat, the frequent occurrence of an affection of the speech from paresis of the faucial muscles, and the absence of previous disturbance of the accommodation, all combine to make the differential diagnosis easy.

Weariness of the accommodation may supervene upon continuous strain of the eyes in excessively fine work, or in work whose fineness is excessive relatively to the individual capacity of the eyes. In this class of cases there is generally something wrong in the conditions of illumination under which the person habitually works, or some deficiency in the acuteness of vision, necessitating the holding of the book or of the work unusually near to the eyes, and so making excessive demands upon both the accommodation and the convergence. Irregular astigmatism from irregularity of the cornea following keratitis or corneal ulcers, dazzling of the retina by diffused light transmitted by corneal scars, effusions in the field of the pupil, structural defects in the crystalline lens, etc., may thus disable the eyes for continued exertion by making it impossible to distinguish small objects except at an abnormally short distance; but these are essentially cases of imperfect vision, and are not properly to be classed with asthenopia.

Regular astigmatism, also, may give rise to symptoms more or less closely resembling asthenopia, through the incidental impairment of vision at all distances, and also, in certain cases, by giving occasion for rapid changes of accommodation without corresponding change in the convergence. (See Astigmatism.)

The accommodative function may be impaired as a result of immoderate exercise under unfavorable conditions, such as close application in sewing upon dark fabrics, reading during convalescence from illness, etc. (*asthenopia ex hyperopsia*), and the disability thus acquired may be indefinitely prolonged through subsequent disuse of the eyes (*asthenopia ex anopsia*). These, again, are, properly speaking, not cases of asthenopia, but of strain of the accommodative organs and its consequences; they are, moreover, generally curable, at first by enforced rest of the eyes, together, perhaps, with the use of atropia, by protecting the eyes from strong light with dark glasses, etc., and later, by bringing the eyes again into use through the agency of carefully graduated exercise in reading, giving perhaps temporary assistance by convex glasses, and gently stimulating the torpid accommodation by the careful use of a weak solution of pilocarpine.

A condition of hyperæsthesia is not infrequently developed, generally in persons of irritable temperament, which manifests itself by over-sensitiveness to light, or by discomfort or pain in the eyes, headache, dizziness, nausea, or other nervous symptoms, after even moderate use of the eyes in near work. Such cases are more frequently observed in women than in men, and oftenest in women in comparatively easy circumstances, or who lead a sedentary rather than a physically active life. Such patients often suffer from impaired digestion and nutrition, constipation, menstrual and uterine derangements, etc. In general they need careful medical and hygienic supervision, regulation of the diet, correction of constipation by daily small doses of laxatives, combined, perhaps, with belladonna or hyoscyamus, or with strychnia, iron, or arsenic, etc. Refractive errors (hypermetropia, anisometropia, astigmatism, etc.,), so slight as ordinarily to be of no consequence, may also require correction by means of very carefully adjusted glasses. The regular use of the eyes in reading should be encouraged, at first for only a few minutes at a time, increasing by very gradual additions as the patient acquires confidence and the eyes gain in capacity for exertion.

A special type of ocular hyperæsthesia, closely resembling that just referred to, has been described by Förster, and named by him *kopiopia hysterica*. This affection stands in the closest relation to parametritis, and is generally rebellious to all therapeutic measures directed to the eyes; its course is extremely tedious, but recovery takes place when the pelvic disease has finally run its course.

Muscular Asthenopia.—As in hypermetropia, with accurate convergence, the overloaded accommodation is forced to perform its work at a disadvantage, so in myopia the partial or total relaxation of the accommodation in near vision may give rise to conditions unfavorable to the perfect and easy exercise of the convergence. As a consequence of the close physiological connection between the two adjustments, the voluntary effort to accommodate evokes a corresponding degree of convergence, and the effort to converge evokes a corresponding degree of accommodation. In hypermetropia, as has been already stated, either the convergence may be accurately adjusted for single vision with the two eyes, and the corresponding degree of accommodation may then be insufficient for distinct vision at the distance of the point of intersection of the visual axes, or the accommodation may be exerted to the degree necessary to admit of distinct vision, and the correspondingly excessive impulse to converge may lead to crossing of one of the eyes. So in myopia, normal convergence may be associated with useless or harmful tension of the accommodation, or the relaxation of the accommodation necessary for distinct near vision may be associated with insufficient tension of the recti-interni muscles, thus necessitating a special voluntary effort to maintain single vision with the two eyes and so leading to muscular fatigue, or, in default of this special exertion, permitting one of the eyes to diverge (relatively or positively), to the sacrifice of binocular vision.

Fatigue of the recti-interni muscles is mentioned by Scarpa (1801) as an occasional cause of asthenopic symptoms, and it was at one time the fashion to invoke disordered action of the external muscles of the eyeball as the principal cause, and to extol the division of one or another of these muscles as the principal remedy in asthenopia generally. But the recognition of muscular asthenopia, as a distinct type, became possible only after correct views had come to be held regarding the nature and mechanism of accommodation; and its connection with myopia was only shown after the accurate study, by Donders, of the accommodation in its relation to the errors of refraction.

Muscular asthenopia is a direct result of the persistence of the physiological connection between accommodation and convergence, notwithstanding the displacement of the farthest point of distinct vision (*far point*, *r*) in the myopic eye. If, for example, we assume a myopia of 4 dioptrics, the far-point (*r*) will be only one-fourth of a meter (25 ctms.=10 inches) from the eye, and this will be the greatest distance at which fine print can be distinctly seen under full relaxation of the accommodation. But full relaxation of the accommodation is, under normal conditions, associated with full relaxation of the convergence, whereas the requirements of single vision

demand a convergence of four *meter-angles*.* The relation normally existing between accommodation and convergence must therefore be materially altered in order to admit of distinct binocular vision at or near the far-point (r) in myopia, and such altered relation is, in fact, observed in the greater number of cases. But myopia is, as a rule, an acquired affection, and is often of quite rapid development, in which case the necessary adaptation may fail to keep pace with the change of place of the far-point (r), and a state of conflict between accommodation and convergence may arise. In this conflict the convergence is oftenest the victor, for the reason that, on the one hand, double vision, when first developed, gives rise to very great confusion of sight, and, on the other hand, excessive accommodation involves no other immediate inconvenience than that of holding the book or work nearer to the eyes. In other cases, however, the habit is formed of relaxing the accommodation in order to see distinctly at or near the far-point (r), and a special effort of the will may then be required to effect the necessary convergence. The fatigue which attends this effort to maintain the convergence, with relaxation of the accommodation, constitutes muscular asthenopia.†

Regarding the curability of asthenopia diametrically opposite views have prevailed at different times. Until the dependence of accommodative asthenopia upon hypermetropia had been demonstrated by Donders, it was generally believed to be curable, at least in certain cases, and the means adopted were such as we now recognize as tending in some measure to bring about a state of improved co-ordination between accommodation and convergence, namely, the use of convex glasses of the longest focus compatible with the comfortable use of the eyes, which glasses were afterward to be exchanged for others of progressively longer focus, in the hope of being ultimately able to dispense with them altogether. That this plan of treatment was not an altogether irrational one is evident from the experience of the very considerable number of young hypermetropes who are able to use their eyes freely in prolonged near work, a fact entirely in accordance with the observation of Donders, that, with parallel visual axes and also with moderate convergence, the hypermetropic eye is able to bring into use much more of its accommodation than can the emmetropic eye under the same convergence. Moreover, it is not uncommon for asthenopic symptoms, occurring in connection with hypermetropia of moderate grade, to disappear after a few weeks or months of relief from strain afforded by the use of weak convex glasses in reading and study. In these cases the glasses give great relief when first worn, but, by and by, the need of them is less urgently felt, so that the child begins to do without them, and at last forgets to use them at all. But these cures, however satisfactory they may be for the time being, are apt to be followed by relapses, which may again yield to a new course of treatment, until with increasing age, and the accompanying restriction of the range of accommodation, convex glasses become indispensable.

Asthenopia may also be treated by acting directly upon the accommodation by the methodical use of myotics. In his original study of the action of Calabar bean, Donders observed that the range of accommodation is positively increased after the instillation of this drug, and that this increase, which is most considerable after about two hours, diminishes quite slowly. He observed, also, a material increase in the accommodation as related to the convergence, which measured rather more than 0.8 dioptric eleven hours after the instillation, and he made the very significant remark that "hypermetropes, under the double advantage of smaller circles of diffusion and of easier tension of accommodation, lose for a time their asthenopia." The introduction of pilocarpine in ophthalmic therapeutics has made it practicable to keep up a moderate myotic action for an almost indefinite period, and with insignificant spasm of accommodation. In cases of asthenopia in young persons, associated with hypermetropia of low grade, pilocarpine may be employed in the form of a weak solution (0.25 per cent.), instilling about 0.1 minim, measured by means of a slender glass pipette. The instillation may be made morning and evening, and after a few weeks at night only; or the effect may be gradually diminished by reducing the strength of the solution. In this way it is often practicable to tide over an attack of asthenopia in a young person, without interfering with school work, and to postpone the use of glasses for perhaps many years.

In asthenopia dependent on hypermetropia of a high grade, the only resource is in the use of convex glasses, and these should be of a strength sufficient to correct fully the refractive error. Owing to the fact that a part of the hypermetropia is almost always latent (see Hypermetropia), fully correcting (neutralizing) glasses often prove less acceptable in the beginning than those of longer focus, but in every case the selection of glasses should be made with distinct reference to the total hypermetropia, and in the expectation of ultimately applying the full correction. In a few cases of asthenopia any exercise of the accommodation, whether with or without glasses, is attended with pain, so that it may be found necessary to have recourse to atropia for the purpose of maintaining for a time a state of complete physiological rest. During the maintenance of the mydriasis reading may be permitted with the aid of strong convex glasses, which must be exchanged for neutralizing glasses when the accommodation is allowed again to perform its function. The hypermetrope who requires convex glasses for reading sees also perfectly at a distance with the same glasses, and, as a rule, finds it more convenient and comfortable to wear them constantly; but in this he may generally be permitted to follow his own pleasure. If for any reason he is disinclined to wear glasses constantly, a compromise may generally be effected by prescribing spectacles for reading and an eye-glass (*pince-nez*) for occasional use.

In muscular asthenopia complicated by positive insufficiency of the recti-interni it is often necessary to give some measure of direct aid to these muscles, either by the decentration of the concave glasses, which must be so mounted that the distance between the centres of the two lenses shall be greater than the distance which separates the centres of the two corneæ, or by grinding the required concave spherical or spherical and cylindrical surfaces upon prisms of from 2° to 8° angle. These prisms may generally be exchanged after a time for weaker prisms, or their effect may be diminished by lessening the distance which separates them. In cases of greater insufficiency of the recti-interni prisms are inapplicable, and the only available resource is in the division of the rectus-externus muscle in one or both eyes; but this ought to be undertaken only after an exhaustive investigation of all the elements of the case.

* The *meter-angle* is the measure of the convergence when the two eyes are directed to a point one meter distant, and, in the emmetropic eye, corresponds to one dioptric of accommodation. In convergence for a point 3, 2, 1, ½, ⅓, ¼, etc., meters distant, the convergence is said to be of ⅓, ½, 1, 2, 3, 4, etc., meter-angles, and the accommodation (in emmetropia) is similarly of ⅓, ½, 1, 2, 3, 4, etc., dioptrics.

† The conditions which determine the development of asthenopia may be stated in a general form as follows:

In the normal condition of the eyes (emmetropia), under an exercise of the accommodation equal to n dioptrics, each eye is adjusted for distinct vision at a distance of $\frac{1}{n}$ meter, and with this accommodation of n dioptrics there is associated a degree of convergence equal to n meter-angles; the visual axes intersect, therefore, at the exact distance ($\frac{1}{n}$ meter) for which the two eyes are severally accommodated, and the two adjustments are performed in perfect harmony.

In hypermetropia a certain exercise of the accommodation, say of h dioptrics, is required for distinct vision at a distance, at the same time that the convergence is relaxed to zero (parallelism of the visual axes), and for vision at the distance of $\frac{1}{n}$ meter a degree of convergence equal to n meter-angles must be associated with an exercise of the accommodation equal to $n + h$ dioptrics; the excessive demand thus made upon the accommodation may be attended with fatigue and relative insufficiency of the accommodation (*accommodative asthenopia*).

In myopia, say of m dioptrics, distinct vision at a distance is impossible, and for vision at a distance (within the limits of the region of the accommodation) of $\frac{1}{n}$ meter from the eye, an exercise of the accommodation equal to $n - m$ dioptrics is associated with a convergence of n meter-angles; the relatively excessive demand thus made upon the convergence may be attended with fatigue and relative (or perhaps actual) insufficiency of the recti-interni muscles (*muscular asthenopia*).

In the treatment of asthenopia, whether accommodative or muscular, the chief reliance is to be placed upon the correction of the underlying error of refraction (hypermetropia, myopia, astigmatism, and in certain cases anisometropia) by means of appropriate glasses (convex, concave, cylindrical, or of different foci for the two eyes). A nearly normal relation of accommodation to convergence is thus established, and the glasses which perfectly correct the refractive error in youth suffice until with advancing age the sight begins to be presbyopic (see Accommodation and Refraction, physiology; ditto, pathology; Astigmatism, Hypermetropia, Myopia, Presbyopia, Strabismus, Spectacles). *John Green.*

ASTHMA. Symptomatology.—It is a disease characterized by attacks of true intermittent, but severe, dyspnœa, accompanied by general sibilant râles. In a typical case of the complaint the patient may retire to bed in apparently good health, and with no more warning of the impending attack than in a case of nocturnal epilepsy; but after a few hours' sleep his respiration becomes labored and whistling, so that it even may be heard by others while he is still asleep. Soon he is himself awakened by his difficulty of breathing, though if accustomed to such visitations he may endeavor to continue his slumber, and for awhile succeed in doing so. Erelong, however, not only sleep, but all rest becomes impossible by the supervention of a most urgent dyspnœa, whose symptoms would indicate great peril to life in any other disease. In asthma, however, though the distress be great, alarm is significantly absent from the patient.

Careful observation now will show that the difficulty in the breathing is mainly due to some interference with the *expiration.* Unlike croup, asthma allows the air to readily enter with the inspiration, but the expiration appears as a laborious struggle which succeeds in forcing the air out only with painful slowness, rendering this process from two to four times the length of the inspiration. This disproportionate expiration is characteristic, for though the expiration is prolonged in emphysema and phthisis, yet it never equals the delay of asthma. The patients, therefore, dread the most ordinary acts which entail a prolongation of the expiration, like coughing, or even speaking, but especially laughing, for in some this is itself sufficient to induce an attack, while on the other hand a forced inspiration will often serve to break up the paroxysm.

Owing to this impeded exit the residual air increases in the lungs to such an extent that the intercostal spaces become much widened and the girth of the chest so expanded that the ordinarily worn clothes of the patient will not come together by from one to three inches. The upper abdomen also becomes similarly distended by the forced descent of the diaphragm pushing down the liver, stomach, and spleen. The walls of the chest finally seem too fixed to allow of any but the slightest expansion and retraction in breathing, and this condition gives to the patient a sense of suffocative tightness, as if caused by some external compression. Salter notes also, as a frequent symptom, a persistent itching of the chin, and often between the shoulder-blades and sternum as well, supervening with the first symptoms of asthmatic breathing and passing off with the full development of the paroxysm.

Diagnosis.—Physical exploration of the chest now affords a group of characteristic symptoms which render the diagnosis of asthma a matter of no great difficulty. The lung distention exaggerates the pulmonary resonance on percussion and extends its area in every direction, behind the clavicles, over the heart, and downward over the regions of normal splenic and hepatic dulness. From the same cause the vocal fremitus either disappears or is much diminished in those localities where it is well marked in health. Auscultation, however, is the most decisive in its indications, for the normal vesicular murmur is quite displaced by high-pitched sibilant râles, which often attract the attention of bystanders, as they become audible to some distance from the patient. On applying the ear to the chest, however, one distinguishes very fine râles, mingled with others larger and graver in tone, and which, moreover, seem to shift in location as if sometimes near to the ear, and then further off, like a wavy passage of air over various musical tubes. In simple asthma these râles are purely sibilant, but in prolonged attacks, or when bronchitis is also present, they become more or less crackling.

As the disordered respiration continues, the sufferings of the patient for breath become extreme. His whole frame partakes in the struggle for air, which leads him involuntarily to try to expand the chest yet more and more. He strives to make immovable his back, shoulders, and head, so that from them the accessory muscles of respiration may pull upon the already tense walls of the thorax. Hence he fixes his arms or plants his elbows on a table or other support, while his head is thrown back, his mouth panting, his eyes widely opened and fixed, and his face pale and bedewed with perspiration. He speaks only in monosyllables, and resents everything which calls him off, even for a moment, from his efforts to breathe. The pulse grows small and feeble, and the patient becomes so cyanotic and cold that his wet, clammy skin and ghastly expression are apt to inspire strangers with fear of his near dissolution.

The duration of an attack varies greatly, not only in different patients, but in the same patient at different times. The attack may come on in the night and pass off soon after daylight, or it may be prolonged into a series of exacerbations and incomplete remissions for several successive days and nights, until the sufferer becomes almost fatally exhausted. In like manner the subsidence bears little relation to its severity or duration. Either as the effect of remedies or spontaneously, the breathing may become suddenly easier, the rigidity of the chest-walls pass off, the inspirations grow fuller, and the expirations shorter, and the patient, who, but a few moments before, seemed about to perish in his distress, will soon return, after a moderate expectoration of a clear frothy mucus, to regular and natural breathing, with no other indication of his recent sufferings than an expression of fatigue. At other times, especially if bronchitis supervenes, the attack passes off in a series of irregular paroxysms of difficult breathing, alternating with coughing and free expectoration. In many fully developed attacks, however, the patient has carefully to watch for its decline by avoiding all causes of exacerbation or relapse, especially from eating, so that some asthmatics are obliged to go to bed fasting if they are to pass that night free from dyspnœa.

Etiology.—In asthma, as in other markedly spasmodic diseases, the afferent impression which induces the attacks varies indefinitely, both in kind and in seat. The sensory nerves, however, which are distributed to the mucous membrane of the respiratory tract, including the olfactories, afford the most frequent instances of the curious impressibility which excites reflexly the asthmatic spasm. On this account bronchitis itself takes the lead, for asthmatic breathing occurs in so large a proportion of both acute and chronic forms of this affection that some writers have gone the length of ascribing all asthmas to bronchitis. It is easy to show, however, that asthma lacks no element of a true neurosis, and that in many typical cases there is no bronchitis whatever. Yet, so great is the proclivity to it in bronchitis, that even comparatively transient affections, like measles and pertussis, sometimes entail a life-long asthma as a sequel to the bronchial irritation attendant upon their course. In the initial, or "dry" stage of acute bronchitis, along with the sense of soreness and tightness across the chest, auscultation reveals the presence of true asthmatic wheezing, while in chronic bronchitis asthmatic attacks often occur upon very slight provocations, such as by rising too suddenly, or from attempting too long a sentence in talking.

After the irritation of bronchitis, the list of excitants of asthma which take their start from the sensory nerves of the respiratory mucous membrane varies in a most extraordinary degree. Nearly every asthmatic has his specialty of the kind, so to speak, often with a most un-

accountable caprice of choice. The writer has known of a gentleman who, while in his room on an upper floor, yet could tell at once by his breathing that buckwheat flour had been just brought into the house. The proximity of certain animals, especially cats, will induce an attack with many asthmatics, who may suffer from this cause for a long time without being aware of its origin until they accidentally discover that the tightness comes on so soon as they come near a horse or a dog, or pay a visit to a menagerie. The proclivity to asthma from deranged innervation within the nasal cavity is also illustrated by numerous histories of cures by the removal of polypi or other causes of nasal obstruction or irritation. The smell of powdered ipecacuanha is often mentioned as a similar excitant, but although this may be ascribed to irritation by minute particles of ipecac inhaled—and the like may be said of asthma from the inhalation of mustard or of the fumes of a sulphur match—yet such an explanation cannot hold good in asthma caused by the smell of violets or of other fragrant flowers. In fact nothing can be more whimsical than the behavior of asthma as regards either what may be resented as an ingredient of the air inspired, or simply from the general character of the outer atmosphere. One asthmatic may find comfort in the air of a particular locality which another asthmatic can enter only at his peril. Salter mentions the instance of two friends who could not exchange visits at their country houses, which were on opposite sides of a ridge, though both were suited with the air of London. The air of large cities, in fact, despite of its smoke and dust, agrees oftener with asthmatics than does the pure air of the country.

Next to the respiratory tract, the most frequent excitants of asthmatic attacks proceed from the alimentary canal, especially from its gastro-duodenal portion. Most asthmatics, indeed, are also dyspeptics, and are thus doubly obliged to be particular in their dietary. The list of forbidden articles is singularly varied, as we might expect from the range in this respect among dyspeptics as a class. Some will have asthma if they take cheese, others almonds, others apples or wine or tea or tobacco, etc.; the peculiarity being that the particular idiosyncrasy is generally consistently adhered to, perhaps for many years, or at least as long as natural tastes or likings are apt to last. With many patients, however, it is not so much a particular article which brings on a paroxysm, but a too hearty meal for them of any kind. On the other hand, constipation is the sure provocative with some who are also often promptly relieved by a cathartic. In women, uterine derangements have their share in the causation of asthma, though not as frequently as they serve to excite other spasmodic diseases; while a certain proportion remains whose attacks seem to be induced solely by mental excitement, particularly of a depressing kind.

Among the special predisposing causes of asthmatic seizures is the state of sleep, for the majority of distinct attacks set in after the patient has been asleep for some time, and oftenest during the hours of profound slumber, after midnight. Some asthmatics are obliged to keep awake after noting certain of their usual premonitory signs, or the attack will surely develop if they happen to sleep at all. The relation of sleep to the attacks is also well illustrated in peptic asthma, for though the offending article of diet be taken in the morning, yet it will not be until its customary hour in the night that the asthma which it induces will come on. This chronometry of asthma exemplifies the real but unperceived continuousness of the spasmodic nervous diseases, in all of which the outbreaks are sudden only in the manifestation of certain symptoms, and which mere symptoms, like spasm, etc., are therefore too often mistaken for the whole disease. The reasons which have been adduced by various writers for this nocturnal feature of asthma, as in the analogous instance of nocturnal epilepsy, are too hypothetical to call for extended discussion. It is interesting, however, to note that the mere fact of darkness seems to dispose to the attacks. Not a few patients can prevent them by keeping a light burning brightly in their rooms, while if the light be put out they will soon wake up with difficult breathing.

Asthmatic dyspnœa is also occasionally secondary to other diseases or morbid states, in which case it ranks only as a symptom of them. Thus, in heart-disease, particularly of the mitral valves, the widespread congestion of the bronchial mucous membrane may excite real asthmatic symptoms which, moreover, should not be confounded with true cardiac dyspnœa. In the latter, the patient resembles one who is out of breath from muscular exercise, as after running, but cardiac asthma, properly speaking, shows the same derangement of expiration as ordinary asthma, and is evidently due to the bronchial hyperæmia acting as a reflex excitant. Toxæmia also sometimes produces asthmatic attacks, especially in gout and in uræmia. In the gouty cases the attacks are sudden, nocturnal, and quickly accompanied by a great bronchial flux, which may be pinkish from capillary hæmorrhage. A patient of mine once expectorated two large basinfuls of such mucus between midnight and morning, but after three such attacks they ceased and never recurred afterward. In gouty asthma alarm is wholly absent, but not so in uræmic asthma. Here again, as in the cardiac cases, the dyspnœa should not be mistaken for asthma, if it be due, as it commonly is, to pulmonary œdema or to pleuritic effusion. True uræmic asthma is characterized by sudden attacks of difficult breathing with great terror, and often also with severe palpitation of the heart, which is usually much hypertrophied from the arterial obstruction of chronic renal disease. After a few attacks, if not after the first one, the breathing remains permanently shortened, and the patient dreads the slightest cause of cardiac excitement. In most cases uræmic asthma is a late, and not a favorable symptom of chronic Bright's disease, particularly of the granular variety, and it is commonly associated with abundant light-colored urine of low specific gravity, with or without albumen. In one case, however, seen by me in consultation, the kidney affection seemed to follow the asthma rather than to precede it. The patient, a gentleman about fifty years of age, was suddenly seized, while apparently in perfect health, with extreme dyspnœa. His physician on arrival tested his urine, and found it heavily loaded with albumen. This albumen, however, wholly disappeared in a few days, until after a fortnight, when he had another exactly similar seizure, also in the daytime. The interesting circumstance connected with the second seizure was that he had sent a specimen of urine, passed only an hour before the attack, to be examined, and it was found to be wholly free from albumen and of normal specific gravity, but some tested immediately after the seizure set in, became nearly solid on boiling. This observation of the reappearance of albumen only at the attacks, with its gradual but ultimately final disappearance until another fit of dyspnœa, was repeated a number of times, once by myself, as daily examinations of his water were kept up. He finally succumbed some months afterward to extensive effusions in both pleuræ.

Asthmatic attacks are also sometimes plainly associated with the disappearance of chronic skin eruptions. A patient of mine always became asthmatic whenever an old eczema of the chest began to subside, until he found that he could rid himself of the infliction by an artificially induced eczema with croton-oil.

AGE.—Asthma may begin at any age. An intelligent patient of mine, seventy years old, stated that the disease was observed in him on the first day of his life. There is, however, a special proclivity to it in the first decennial, owing to the predisposition of children to bronchitis. Of 225 cases, Salter had 71 under ten, and in 11 of them it began in the first year. The prognosis of asthma is better in childhood than later on, as it is frequently outgrown after puberty, particularly if the causes of bronchitis be carefully avoided. The cases which begin in adolescence are relatively few, and are then generally of the purely spasmodic form. But in middle life the proclivity to asthma again increases with the greater exposure from out-door occupations, but, unlike bronchitis, asthma as a new disease begins to fall off, and progressively decreases in its ratio till seventy. The common impression that asthma is a disease of old age is a mistake, arising

rather naturally from the frequency of chronic bronchitis with asthmatic wheezing among elderly persons.

SEX.—The influence of sex is considerable, the preponderance of males being about double that of females. That this, however, is due to the greater exposure of men to causes of bronchitis, is shown by the fact that the cases of the pure spasmodic variety are about equally divided between the sexes.

HEREDITY.—Asthma belongs also to the markedly hereditary diseases, as might be expected from the characters of its common accompaniments. An inherited proclivity to bronchitis is observable as often as a family tendency to phthisis, while neuroses, on the other hand, are more frequently of constitutional origin than any other class of affections. About thirty-five per cent. of all asthmatics, therefore, will show some sign of heredity, and oftener from the paternal than from the maternal side—a fact, moreover, in keeping with the greater frequency of the disease among men.

PATHOLOGY.—Asthma has no characteristic anatomical lesions. That extensive pathological alterations are often found post mortem is quite true, but in most cases they are caused by intercurrent affections, particularly by bronchitis. Under this head come hypertrophy of the circular muscular fibres, with consequent narrowing of the bronchioles, it may be even to occlusion, collapse of lobules, emphysema, and dilatation of the right side of the heart, with the various sequelæ of these conditions, to be detailed in their proper place (see Bronchitis). But there are some organic alterations which may be ascribed to the labored respiration of asthma alone, when severe and prolonged attacks come so often that the parts have no opportunity to return to their normal state during the intervals. That this is the occasion of such changes appears from their complete absence in those patients who have perfect intermissions between the attacks. The first of these effects is dilatation of the right heart, caused by long labor in the difficult propulsion of blood through the lungs so soon as apnœa occurs in any form. During a paroxysm of asthma, the left heart and the systemic arteries are relatively empty and the pulse small, while the systemic venous system from the right auricle backward is everywhere overloaded. The heart-beat is then found, not under the nipple, but in the scrobiculus cordis; partly, it is true, from the displacement caused by the dilated left lung, but equally also from the distention of the right ventricle. Another constant result is emphysema, or permanent over-distention of the air-vesicles, caused by the progressive accumulation of the residual air from the imperfect expiration. Emphysema may thus be found in old asthmatics, whether they have had chronic bronchitis or not. Lastly, from the combined derangement of the pulmonary circulation caused by the intermittent apnœa and the permanent emphysema, we have a tendency to bronchial flux to relieve the congested vessels, which finally adds chronic inflammation to chronic hyperæmia, and thus establishes the vicious circle of impeded circulation causing bronchitis, and bronchitis in turn causing progressive circulatory impediment.

These slowly induced effects finally produce those changes of personal appearance which mark old asthmatics. As the general nutrition suffers from the persistent congestion of the liver caused by the impeded outflow of the right heart, these patients are usually thin, pale or cyanotic, and with deficient muscular power. The eyes are prominent and watery, the voice weak, the gait slow and measured, and the back rounded, often to great deformity. The head, however, is always thrown back between the elevated shoulders, and the trunk of the body is kept so rigid that the arms hang passively swung by the movements of walking.

Leyden endeavored to demonstrate the cause of asthma to lie in the presence of sharply-tipped octohedral crystals, found abundantly in the expectoration which terminates a paroxysm of asthma, and which, he supposed, by their numerous fine points set up a reflex irritation of the terminal branches of the vagus in the bronchial mucous membrane. This theory, however, is sufficiently negatived by the discovery of the same crystals in the secretions of other bronchial affections in which there is no asthma. That asthma, instead, is essentially a functional neurosis is readily apparent when the disease is studied in uncomplicated cases, for in them, though there be neither bronchitis, heart disease, nor toxæmia, we have typical attacks developing in association with phenomena which belong to nervous diseases alone. Of such phenomena we would cite, 1. Extreme suddenness of onset, as the immediate asthma caused in some by certain odors. No less sudden also in many cases is its departure, as upon the inhalation of certain fumes. This feature militates also against the theory of Weber, who ascribes asthma to turgescence of the mucous membrane, narrowing the calibre of the bronchi as an acute coryza impedes breathing through the nose. Störck lent support to this view by laryngoscopic observation of tumefaction of the tracheal mucous membrane as far as the right bronchus in an asthmatic during an attack. Bristowe, moreover, cites the rapid subsidence of cutaneous turgescence in some cases of urticaria evanida as affording some support to congestive swelling of the bronchial mucous membrane being a factor in the etiology of asthma. But though it be freely granted that the agonizing struggles of an asthmatic for air may have considerable effect upon the circulation of the bronchial walls, yet the fact remains that no known swelling, however evanescent, vanishes so quickly as some true asthmatic dyspnœas vanish, the patients becoming natural often more speedily than is common after either epileptic or neuralgic attacks. 2. Like other spasmodic neuroses, whether sensory or motor, asthma often has characteristic prodromata of the attacks. One of the most common is a feeling of almost irresistible drowsiness, giving way to which the patient well knows will be followed by the old dread awakening. With some, on the other hand, unusual wakefulness is a sure precursor. As in epilepsy and in migraine some are warned by the temper becoming very irritable, or the spirits causelessly depressed, while others experience unwonted buoyancy of spirits. Moreover, as in these neuroses, the attacks are sometimes preceded, but oftener followed, by an abundant flow of pale, limpid urine. 3. Mental influences alone are known both to excite and to suspend the attacks with some. In certain patients a fit of anger may induce an attack immediately, in others, more significantly still, invariably insure the attack during the succeeding night, long after the angry emotion is gone or forgotten. 4. It is only in functional neuroses that we find many and widely differing exciting causes. Thus epilepsy has been wholly relieved by the expulsion of a tape-worm, or of a renal calculus, or by trepanning. But in this respect asthma surpasses all other complaints, and the bearing of this fact upon the nervous character of the disease appears when contrasted with bronchitis, which involves, moreover, just the same parts which asthma affects. Bronchitis certainly, as well as any other disease with palpable lesions, cannot be excited by such a motley array of influences as the smell of cats or of violets, the eating of raisins or nuts, by constipation, by depressing emotions, or by the extinguishment of a light. 5. A decisive consideration is to be noted also in the intermediate condition between the paroxysms. In typical asthmatics in whom no organic changes have yet been induced, such as emphysema or the effects of chronic bronchitis, the existence of asthma cannot be even guessed. The patient shows to inspection and to physical exploration of the chest no more signs of being subject to violent and prolonged attacks of dyspnœa than an epileptic's muscles tell of his convulsions.

MECHANISM.—Asthma, therefore, may be regarded as essentially a derangement of the innervation of the respiratory apparatus, disturbing the rhythmical succession of contraction and relaxation by a muscular cramp, which interferes chiefly with the act of expiration. But the mechanism, so to speak, of the asthmatic paroxysm itself is by no means agreed upon. The majority of authorities ascribe it to narrowing of the bronchioles by spasm of their muscular coat, while others maintain that it consists in spasm of the diaphragm and costal muscles. Each of these theories may be said to explain what the other leaves unexplained, and hence it is doubtful if either of them

alone can be regarded as adequate. The arguments in favor of the latter theory are :

1. During the attacks the whole aspect of the patient is that of extreme external muscular rigidity. Both the thorax and abdomen appear fixed and immovable, and show none of those strong heaving and expansive efforts which are visible in other forms of dyspnœa. Thus, in asthma, the diaphragm remains depressed, as if arrested in inspiration, and the muscles of the distended abdomen grow hard and tense as they labor in vain to overcome the resisting diaphragm and thus assist expiration. From the powerful contraction of the abdominal muscles it even happens that the lower ribs often bulge during the effort at expiration. On the other hand, when there is obstruction in the respiratory tract, as in laryngeal croup, œdema glottidis, etc., the phenomena are all different. The difficulty is then plainly in the inspiration, and not in the expiration, and the ribs to which the diaphragm is attached actually sink in, even during inspiration. Why obstruction in the bronchi should reverse all these effects is not explained.

2. The theory of bronchial spasm fails to account for the difficulty of expiration in asthma. If contraction occurs in the tubes, it must interfere with both inspiration and expiration equally, unless it can be shown that the circular fibres have a valvular action at the points of contraction, admitting the incoming, but interfering with the outgoing, current. This phenomenon, however, has never been induced in animals experimentally, and is even difficult to imagine. Moreover, that nothing of the kind occurs is proved by auscultation, for a valvular obstruction to the expiration would totally alter both the quality and the pitch of the expiratory sibilus, which is not the case.

3. On the other hand, the theory of diaphragmatic spasm explains why inspiration is easier than expiration in asthma, because it is well known that partially cramped voluntary muscles, like the diaphragm, can always be stimulated to further contraction, though still disinclined to yield to relaxation. This appears strikingly in tetanus, where the tonic rigidity of the muscles never wholly gives way, although every few moments fresh and powerful contractions occur in response to the slightest external impressions. Meantime, the statement that the depressed state of the diaphragm is a passive condition due to the over-distention of the lungs with residual air, is negatived by the active muscular contraction of the abdomen above referred to, which is quite different from the passive distention of the abdominal walls when the diaphragm is depressed in emphysema.

4. The asthmatic paroxysm is always aggravated by certain movements which confessedly occur only in the diaphragm itself. Patients, on this account, especially dread to laugh, or to do anything which slows or checks the relaxation of the diaphragm, such as long talking. But how these actions could in any way affect bronchial constriction is difficult to conceive.

On the other hand, there is one incontestable proof that constriction of the bronchi does take place in every case of real asthma, and that is the invariable presence of general sibilant râles of every variety of size, from fine whistling to large cooing sounds. In true asthma these sounds are purely tubular, and from their shifting character, above alluded to, it is plain that they are produced by progressive waves of contraction in the bronchial walls, and not by a uniform diminution of their calibre, such as general tumefaction (Weber) would occasion. These râles, moreover, are simultaneous with the onset of the attack, as they are audible sometimes in the breathing of an asthmatic, even before he is awakened by a fit, and so constant are they that no dyspnœa can be termed asthmatic if there be no wheezing. Now, the theory of diaphragm spasm wholly fails to account for these characteristic bronchial râles. If we had diaphragm spasm alone, the symptoms then would rather resemble *burking*, or, more properly, the dyspnœa which is often the fatal complication of tetanus, where death results from tonic spasm of the respiratory muscles. Here, as I have had personal occasion to note, there is no wheezing whatever.

From these considerations the view of Lebert seems to us preferable, namely, that the asthmatic paroxysm begins with spasm of the bronchial muscles, much as the first discharge of epilepsy often begins with a special group of muscles, and then spreads to other and wider muscular associations. Considering how intimately and constantly the muscular actions of respiration are associated, it is easy to conceive how disordered innervation of the bronchial muscles may become quickly accompanied by disordered innervation of the diaphragm, and thus check the return of inspired air. Some ten such respirations would suffice to inflate the lungs to the extremest degree observable in asthma, until the whole muscular apparatus of expiration would join in the spasm and complete the picture of this dyspnœa, where almost the only movements which remain in the distressful breathing are the lifting actions of the neck and shoulder muscles. Lebert justly insists on the contrast between the pulmonary dilatation in asthma and its absence in fibrinous bronchitis, where, though the obstruction is great and the constriction of the bronchioles a tubular narrowing, yet there is but slight dilatation, if at all, and which proves, therefore, that something more than bronchial constriction is needed to explain all the clinical features of asthma.

Treatment.—Much the greater number of reputed remedies for asthma are little else than palliative, because their operation merely relieves a paroxysm or attack of the complaint, just as opium may relieve the pain of a syphilitic node without producing the least effect on the cause of the symptom itself. The peculiar motor spasm of asthma is not the disease, but only a symptom of it, the same in nature with pain, and hence, like other mere symptoms in nervous diseases, it can be affected by a great variety of influences. Thus such unlike agents as caffeine, chloral, ether, and tobacco, or the inhalation of stramonium or of nitre fumes, are each spoken of as marvellously relieving certain confirmed asthmatics. No sooner does the patient begin to experience the special effects which these drugs produce in a healthy man, than the agony of his breathing subsides, and a restful calm succeeds as by magic. But the great disappointment with these seemingly effective remedies is that the longest use of them brings the patient no nearer getting rid of his enemy than when he began. He may break up his attacks for years with his special prescription, but the asthmatic fit is as ready to return, and as severely, as if no remedy for it ever had been tried.

The reason for this failure is fundamental. These so-called remedies for asthma are all neurotics, and no agent like opium, or aconite, or stramonium, or ether, whose whole medicinal action is obtained by one dose, can do anything more than that one dose does. However often repeated no cumulative progressive effect follows upon the administration of neurotics, and hence they can affect only the functional manifestations of a constitutional disease. All that such medicines can do is to produce some immediate but temporary change in some symptom of the complaint, but no more. There is hence a parallel between the curious variety of the exciting causes of asthma in different persons, and the like variety both in the neurotics themselves and in their disproportionate efficacy in different patients. For while the exciting causes show by their incongruity that they are not true but only accidental elements in the case, so the diverse neurotics recommended for asthma show that they affect only some accessory, but not essential factor in the disease. When a nasal polypus makes one patient an asthmatic and a loaded rectum another, neither of these cases throws the least light on the true cause of asthma. Likewise when a nauseant emetic and a glass of hot spirits and water are each said to "work like a charm" in some asthmatics, we can scarcely say of such remedies that they bring us nearer the true therapeutics of the malady, for it is plain that they modify only some chance association of perverted function.

In this class of palliative remedies we would assign the first place to the mydriatics, belladonna, hyoscyamus, stramonium, and duboisia. The wide range of disorders

in which these medicines have been found beneficial is due to a general principle in their operation, which also suggests the explanation of their use in asthma, viz., that they relieve disordered innervation of involuntary muscular fibre by a motor stimulant action which restores its rhythmical contraction when it has been arrested by spasm from any cause. Spasm and paralysis are associated phenomena in unstriped muscle, tetanic contraction of one portion and relaxation of the remainder taking the place of the normal wave movement throughout the whole. Hence the use of belladonna and its allies in spasmodic action of the bladder in cystitis, in nocturnal incontinence of urine, in the constipation of women from reflex pelvic irritation, in spasmodic gastrodynia, in cardiac pains when due to left hypertrophy deranging the rhythm of the two sides of the heart, etc. As with other neurotics, the earlier they are given in the attack, the more pronounced and speedy is the effect. A full dose of the tincture, or of the fluid extract of belladonna, should be given, enough to produce well-marked constitutional effects, and then repeat the same in two hours if there be only imperfect relief. If the second dose fails to affect the breathing, a very effective method is to give a hypodermic of atropia injected deeply into the nape of the neck, a locality which is the seat of a sensation of great weariness in severe attacks of asthma, and which this measure often mitigates at once, after other employment of the remedy had failed. Hyoscyamia sometimes affords more relief than atropia, but in most cases is not superior to it. Other patients are best relieved by the inhalation of the smoke of stramonium leaves, for which purpose they may be lit at the bottom of a cup, or used like tobacco in a pipe or made into cigarettes; the effort being to inhale the fumes as deeply as possible, when the dyspnœa sometimes is found to vanish with surprising rapidity.

Coffee should be reckoned also among the neurotics which are effective in asthma by a stimulant action. It should be made very strong, taken always on an empty stomach and taken hot, for the sipping of the potion is not without its own effect, as it has been shown by Krönecker that the act of swallowing itself powerfully stimulates the cardiac and pulmonary branches of the vagus. Coffee taken after eating aggravates asthma by interfering with digestion. In some cases I have found the alkaloid, caffeine, of temporary benefit, but on the whole regard it as inferior to the freshly made and strong infusion. Hot coffee is particularly good in asthmatic bronchitis, as it facilitates the expectoration while it relieves the spasmodic condition. It is in the same class of cases also that the muscle stimulant, nux vomica, is sometimes beneficial. Here again the tincture or the fluid extract of the drug are preferable to its alkaloid, strychnia.

Next in order come the neurotics which probably relieve the asthmatic paroxysm by a sedative action on the initial irritant impression. Among these we would enumerate alcohol, the ethers, chloral, and opium. It should be noted that while alcohol is a stimulant to the heart and to some cerebral functions, it is an immediate sedative to the sensory nerves, and this sedation steadily increases in proportion to the dose. Sulphuric ether, when taken internally, resembles alcohol in these respects, though much more pronounced in its sedative effects. Hence the use of both alcohol and ether in the muscle-cramp of intestinal colic and in spasmodic affections of ducts generally. Full doses of spirits, therefore, taken hot, will relieve some asthmatics to the exclusion of all other remedies, but the relief does not occur generally until enough is taken to intoxicate a well person, though it rarely does so with an asthmatic. Sulphuric ether, however, is much more generally effective, especially in the preparation of the spiritus compositus, or Hoffman's anodyne, owing to the oil of wine which it contains. As this latter ingredient is expensive, it is sometimes fraudulently omitted, with a plain falling off in remedial power over the attacks. The dose for the paroxysm should be not less than two drachms. As the latter acts in a different way from the belladonna, being more connected with the sensory element of the spasmodic condition, while the belladonna affects the motor, an unquestionable gain is secured by administering these two remedies together.

As might be expected, there is much contradictory testimony about the value of opium in asthma. This need not be wondered at in view of the widely different effects of opium, *e.g.*, as a soporific, in different individuals. The mode of administration, however, counts more with this remedy than with any other, for the speedy effect of a hypodermic of morphia is much oftener successful than morphia or opium taken by the mouth. This, however, is in accordance with the general rule, that the more quickly a neurotic is felt, the more effective it is against any spasmodic affection, *e.g.*, arresting an epileptic fit by a sudden irritant impression, but which fails if applied gradually. Chloral in large doses, thirty to sixty grains, is claimed as an excellent remedy for asthma, but the patient's tolerance of this drug, sometimes fatal in only fifteen-grain doses, should be well established before this treatment is tried. Inhalations of nitrite of amyl often arrest a commencing attack, but are not of much use in a fully developed paroxysm. The fumes of the nitrate of potash, however, inhaled by burning cigarettes made of rice-paper dipped in a saturated solution of the salt and then dried, are much more generally effective. This remedy undoubtedly acts upon the well-known locally sedative properties of potash itself, and hence may well co-operate with the different action of the fumes of stramonium leaves rolled up with the nitre paper.

Lastly we have the pure sedatives whose action cannot be secured until nausea has been occasioned by them. Asthmatic spasm, like every other cramp, rarely holds out against the sickening effect of tobacco, lobelia, or even of ipecacuanha. Tobacco, therefore, is effective only with those who are not used to it. Lobelia has the disadvantage of producing too much prostration, and the same may be said of tartar emetic. This class of remedies works much better in bronchitic than in peptic asthma.

Besides these there are but few neurotics left in the pharmacopœia which are not recommended by some for asthma, although no one is ever permanently benefited by any of them.

Better results, however, may be hoped for from efforts directed to other aims than simply to relieve a fit of the dyspnœa when present. Asthma is at no time absent from the asthmatic any more than epilepsy from the epileptic, though the manifestations of either are only occasional. Prophylaxis, therefore, assumes an exceptional importance, because, as in other spasmodic neuroses, the malady becomes inveterate in proportion to the frequency of the attacks. As in the case of epilepsy, also, the slightest attacks of asthma are as much to be avoided as the severer ones, if there is to be any hope of the patient becoming ultimately free from them, and hence the exciting causes in each instance should be carefully noted and jealously provided against. In those cases where the susceptibility to odors indicates the upper respiratory tract as the seat of the irritability, the inhalation of carbolized steam should be tried. The steam should be made to surround the head by the simple device of directing it under an umbrella, held low by the patient himself, so that he may inhale without more effort than in ordinary respiration, because breathing by will is too fatiguing a task to be kept up for long by anyone, and it is this fact which accounts for the uniform failure of the many inhalers and atomizers which have been invented during the past century. This treatment should be kept up twice a day for months, the object being to produce a permanent change in the susceptibility of the sensory nerves distributed to the nasal and pharyngeal mucous membranes. Occasionally the vapor of turpentine may be substituted for that of carbolic acid. It is in these cases also that much may be expected from the French procedure originated by Ducros, of painting the posterior wall of the pharynx with aqua ammonia, though to prevent some being made worse by the irritant fumes, Trousseau recommends inhalations of ammonia first from a phial and then touching the pharynx with a weak solution, to be made stronger as the patient becomes accustomed to

it. Trousseau refers the immunity of many patients from visits of asthma so long as they reside in the vicinity of gas-works, to the presence of ammonia in the air of the locality; but while this possibly may be operative, yet we would ascribe it more to the unmistakable sedative effect upon the bronchial nerves of air charged with creasote, carbolic acid, and other allied products of wood distillation. It is in this class of patients also that the bromides are useful, owing to their paralyzing the reflex excitability of the pharyngeal nerves. A dose of thirty grains of potassium bromide, with a drachm of Hoffman's anodyne at bed-time, will often ward off a nocturnal visit of the enemy.

It is, however, in bronchitic asthma that prophylaxis is particularly imperative. As comparatively few cases of bronchitis originate from direct irritation of the bronchial mucous membrane, but much more commonly from some partial exposure of the skin to unequal degrees of temperature (see Bronchitis), so the particular susceptibility of different cutaneous regions should be tested and preventive measures adopted accordingly. As a general rule, in bronchitis which begins usually with a coryza, it is the nape of the neck, while in phthisical cases it is the anterior surface of the chest, and in pharyngeal or tonsillar cases, the feet, which are the most susceptible to those impressions of passing cold that set up their special tracks of inflammation or hyperæmia in mucous membranes. After a few days' continuance of the catarrhal state, however, the skin of the whole surface partakes in this specific irritability, so that the patients may become aware of a draught from a distant open door which others do not feel. Many cases of bronchitic asthma, therefore, are promptly relieved by putting on a whole suit of buckskin over a light under-flannel, and wearing the same until settled summer weather. These patients also should guard against nocturnal perspiration about the neck and shoulders, by the use of light flannel instead of cotton or linen night-shirts. Daily inunctions of oil also, especially to the feet, and preferably done on rising, do much to lessen the tendency to catching cold. The bronchitis itself, of course, should be treated according to its indications, with especial benefit to be hoped for in asthmatics from the emulsion of linseed-oil. We need also only allude here to the importance of making the utmost of the intermediate summer period of mitigation of bronchitis with many patients, before the malady has become too chronic, as that subject is to be fully discussed under its proper head.

Peptic asthma is so much influenced by the state of the alimentary canal, that some have spoken of the treatment of asthma in general, as if it were mainly a matter of regimen and diet. Indigestible food, even a single meal of such, is to be scrupulously avoided in every form of spasmodic disease. The patient must not endeavor to reconcile his digestive apparatus to any second trial with an offender. Whether the proneness to spasmodic or convulsive disorder be due here to the greater susceptibility of the nerve-centres to reflex excitation from the alimentary canal than from any other nerve distribution, or whether the susceptibility is caused by the absorption of nerve poisons generated in some intestinal fermentation, it is unquestionable that any departure from good digestion is to be dreaded in treating such complaints, and in none more so than in asthma. Experience will teach each one best all the particulars as regards what he can and what he cannot eat, and its verdict must be accepted. Moreover, with all asthmatics, the digestive power decreases as the day wears on, and hence, the best meal should be taken before the afternoon, while in the evening only the slightest supper should be allowed.

But as the prevention of peptic asthma well-nigh involves the treatment of all the varied forms of dyspepsia, we can direct attention here only in a general way to the subject, for each case to be managed according to its own indications. We may remark, however, that bismuth appears to be one of the most effective preventives of peptic asthma, probably owing to its antiseptic properties. A good form of administration is in capsules of five grains each of bismuth carb., and of pulv. calumbæ, two such to be taken an hour after meals and at night. If there be much intestinal flatus, from twenty to thirty grains of soda salicylate is an excellent prophylactic.

In conclusion, we would recommend, besides prophylactic measures, the recourse to certain remedies whose benefit, when secured, can properly be termed lasting or curative, instead of merely palliative. Want of success with them may be due often to a failure to recognize the fact, that to be truly curative in such a deep-seated and life-long malady as asthma, a remedy must be given continuously without reference to the attacks, and long enough to produce a decided modification in the system itself. Such a result never can be obtained from neurotics, however steadily or largely they be taken, as is proved by the absence of any recognizable sign, either in life or after death, of the years spent by many in consuming tobacco or opium. In arsenic and the potassium iodide, however, we possess truly constitutional medicines, whose value in asthma has been repeatedly demonstrated. If these medicines, however, have any effect on asthma, that effect is wholly different in kind from the immediate relief produced by a transient acting neurotic, for it must be by causing a more or less organic alteration in the lesion itself. Their proper administration in asthma, therefore, should be like the administration of iron for anæmia, or mercury for syphilis, or the bromides for epilepsy, the effect being obtained not by one, or by the first dose, but only after months of steady use. I feel assured that if a combined or alternate arsenical and iodide treatment were as systematically adopted in the treatment of asthma, as the above-named constitutional remedies are used in other maladies, that many a case of this disease finally would be got rid of which now, under the deceptive recourse to neurotics, becomes at last an incurable habit of the nervous respiratory mechanism.

To obtain the best results with constitutional remedies, two therapeutical rules should be steadily followed. The first is to administer along with them one or more of the restoratives, in order to prevent the injurious effects of the continued taking of such unnatural substances into the system as arsenic or iodine. No symptoms of iodism or of arsenic should be allowed, because the remedial effects of these medicines cease at once upon any signs of their poisonous operation. If diminishing the dose is not followed by a cessation of the symptoms, they must be omitted for a time, and then resumed in small doses, to be increased again only as the patient can tolerate them. The best restoratives with arsenic are quinine and cod-liver oil, while phosphorus and tr. ferri mur. best prevent the injurious effects of iodine.

The second rule is to secure the co-operation of neurotics, for though these latter cannot be curative in themselves, yet experience proves that they unquestionably promote the action of constitutional remedies when they relieve some of the symptoms of the disease. Thus I have repeatedly noted potassium iodide fail adequately to cure a syphilitic node until opium and conium were added to the prescription. And on the same principle I have been accustomed in asthma to prescribe a combination somewhat as follows: ℞. Kal. Iodid., ʒ jss.; Liq. Pot. Arsen., ʒ j.; Spts. Eth. Sulph. Co., ℥ ijss.; Tr. Belladonnæ, ʒ ij.; Spr. Aurant Cort. ad ℥ vj. M. S.: Two teaspoonfuls in water an hour after meals.

In a certain proportion of cases a curative effect is secured by counter-irritation applied along the cervical and upper dorsal vertebræ. The actual cautery is to be preferred, and one form of this irritation is both effective and readily applied without expensive apparatus, namely, by the hot glass rod. Spots of ink, half an inch or so apart, made along the spinous processes, are to be lightly touched by the tip of a glass rod raised to a white heat in the flame of an alcohol lamp. This simple procedure causes but little pain, and immediately after the application shows a continuous red line as if made by the passage of a hot iron. The application should be repeated about every fourth day.

If there be any history of the alternation of asthma with the disappearance of a cutaneous eruption, an ar-

tificial eczema by croton-oil on the chest, as already mentioned, is often positively remedial if persevered in on the first sign of a return of the dyspnœa. Asthma secondary to other diseases must be treated with them. In the cardiac cases, and in gouty patients as well, a continued use of saline waters, like the Congress or Hathorne of Saratoga, will afford the best prospect of relief.

William H. Thomson.

ASTIGMATISM (from α, privative, and στίγμα, a point) is the name proposed by Whewell (1846) to designate the visual anomaly which results from unequal refraction in the planes of the several ocular meridians.* Accurate measurements of the cornea reveal, in the greater number of eyes, a somewhat shorter radius of curvature in the vertical than in the horizontal meridian, and not infrequently this difference is sufficient to give rise to serious imperfection of vision. As a rule, the meridian of greatest curvature is vertical, or approximately vertical, and, conversely, the meridian of least curvature, at right angles to the former, is horizontal or approximately horizontal. To this rule there are, however, many and conspicuous exceptions.

The crystalline lens, also, may be the seat of asymmetrical refraction, either through inequality of curvature in its several meridians, or through some deviation from perfect symmetry of position as referred to the axis of the eyeball. As a rule, astigmatism originating in the lens is less in degree than that which has its origin in the cornea, and the meridian of greatest lenticular refraction is oftenest approximately horizontal, rather than vertical. Hence the lenticular astigmatism tends oftener to correct than to increase the astigmatism due to the asymmetry of the cornea, and the total astigmatism is more apt to fall short of than to exceed that which would result from the corneal asymmetry alone.

From the fact that neither the cornea nor either of the two lens-surfaces is a perfect surface of revolution, and that not one of these surfaces is quite accurately centred with reference to the axis of the eyeball, it follows that the refraction at each of these surfaces is to some extent asymmetrical, and that the actual astigmatism observed in any eye is the resultant of three asymmetrical refractions. In practice, however, these complications are disregarded, and the determination of the elements of any case of astigmatism is confined to the observation of the refractive anomaly as a whole. The study of the essential phenomena of astigmatic vision may be reduced, therefore, to the consideration of the single case of asymmetry of the cornea.

The characteristic property of a pencil of light after a single astigmatic refraction (or reflection) is that its rays have no common focus, but that all its rays pass through two nearly straight lines, which lie at right angles to the axis of the pencil and to each other (*focal lines*). The construction of such a pencil is shown in Fig. 330, in which L represents a luminous point, A, B, C, D a portion of the asymmetrical refracting surface (cornea), of which the meridian of greatest refraction is vertical, and which for convenience in representation is taken as a square; f^1 the first focal line; and f^2, lying in a direction at right angles to the first, the second focal line. The form of the cross-section of the pencil at other parts of its course after refraction is indicated by the series of parallelograms, *a*, *b*, *c*, *d*, and *e*. Only one of these cross-sections (*c*), lying between the two focal lines but nearer to f^1 than to f^2, has the same figure as the cross-section of the pencil before refraction (namely, a square); all the others are oblong parallelograms, having their longer sides in a direction parallel to the nearer focal line. The distance separating the two focal lines (f^1 and f^2) is called the *focal interval*.

From this construction it follows that if the pencil is cut by the retina at f^1, the luminous point at L will be projected, and consequently seen, as a horizontal bright line, and, similarly, if the pencil is cut at f^2, the point L will be seen as a vertical line. If the pencil is cut by the retina at *c*, the point will be seen as a small spot having the form of the refracting surface, which, in the eye, is determined by the form of the pupil, and is therefore circular. If the pencil is cut at any other part of its course the point will be seen as an ellipse. The section of the pencil at *c* is called the *circle of least confusion*.

If, instead of a single luminous point at L, we take the case of a large number of points arranged along the horizontal line M L N, these points will be severally projected at f^1, each as a horizontal line, and these lines, which coincide one with another in the greater part of their length, will appear fused into a single line lying in the direction of f^1. It follows, therefore, that the line M L N, which may be considered as made up of an infinite number of points, will similarly be projected as a line at f^1. So also a series of points arranged along the vertical line O L P, or the vertical line O L P itself, will be projected as a vertical line at f^2. Lines lying in one or the other of these two directions (parallel to M L N or O L P) are, in fact, the only objects which can be projected by the asymmetrical refracting (or reflecting) surface without great alteration.

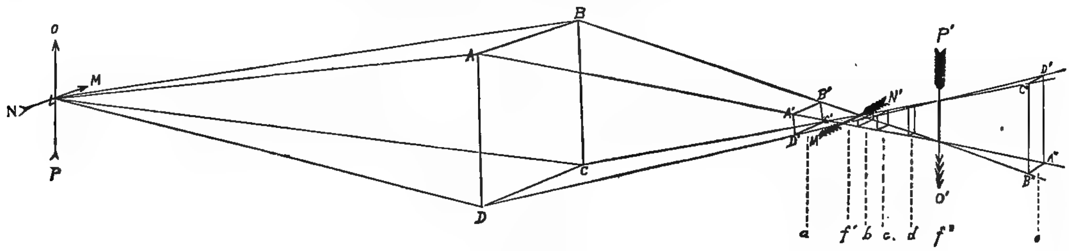


FIG. 330.

The line M L N and the first focal line f^1 lie in the same plane, and similarly, the line O L P and the second focal line f^2 lie in a plane at right angles to the former plane. The intersection of these planes (*principal planes*) with the refracting surface marks the meridians of least and greatest refraction (*principal meridians*), which are also at right angles to each other. It is sufficient, therefore, in any case to note the direction of one of the principal meridians, namely, the meridian of greatest refraction, which is designated by the symbol M_0.

The phenomena characteristic of astigmatic refraction may be shown experimentally by means of a lighted candle, an ordinary convex lens, and a convex plano-cylindrical lens.* The image of the distant candle flame, which may be considered as equivalent to a distant luminous point, is first received upon a screen placed at the

* For convenience, the familiar system of lines and circles used in geography is extended to the topography of the eyeball. If we designate the centre of the cornea and the central fovea of the retina as the anterior and posterior poles, the line connecting them is the axis; all great circles passing through the two poles are meridians; the great circle which cuts all the meridians midway between the poles is the equator; and the portion of the surface included between any two parallels is a zone.

* A plano-cylindrical lens has one of its surfaces plane and the other ground to a cylindrical curve, which may be either convex or concave. Lenses are also ground with a convex or concave spherical surface on one side and a convex or concave cylindrical surface on the other side, and may be imitated by cementing together, by their plane surfaces, an ordinary plano-convex or plano-concave lens and a plano-cylindrical lens. Such a combined lens is called a spherico-cylindrical lens.

principal focus of the spherical lens, where it will be projected as a very small bright spot. If now the convex-cylindrical lens is placed immediately in front of or behind the spherical lens, this bright spot will be seen drawn out into a bright line representing the second focal line (f^2), and by moving the screen nearer to the combined lens a distance will be reached at which the bright spot will be seen drawn out into a line at right angles to the first, and representing the first focal line (f^1). In moving the screen from the second to the first focal line, a point will be passed at which the image of the flame is seen expanded into a small circular disk, reproducing the circular outline of the lens (circle of least confusion); at all other distances the projection will be elliptical in form, with the longer axis of the ellipse in the direction of the nearer focal line.*

To study the phenomena of astigmatic vision, it is only necessary to look through a weak cylindrical lens held before the eye or mounted in a spectacle frame. If the eye is emmetropic (see Accommodation and Refraction, Physiology), a convex-cylindrical lens will render it short-sighted (myopic) in the meridian at right angles to the axis of the cylinder, and, conversely, a concave-cylindrical lens will render it over-sighted (hypermetropic) in the same meridian; thus reproducing the two types of simple astigmatism, namely, *simple myopic astigmatism* (Am) and *simple hypermetropic astigmatism* (Ah). If the eye is myopic, or is made so for the experiment by means of a convex-spherical lens, the convex-cylindrical lens will render it more myopic in one meridian; and, similarly, if the eye is hypermetropic, or is made so by means of a concave-spherical lens, the concave-cylindrical lens will render it more hypermetropic in one meridian; thus reproducing the two types, *compound myopic astigmatism* (M + Am), and *compound hypermetropic astigmatism* (H + Ah). A fifth type, called *mixed astigmatism* (M + Ah or H + Am), is reproduced in the emmetropic eye by looking through a convex- or concave-spherical lens combined with a concave- or convex-cylindrical lens of shorter focus; in the myopic eye, by looking through a concave-cylindrical lens of a strength in excess of the degree of the myopia; and in the hypermetropic eye, by looking through a convex-cylindrical lens of a strength in excess of the degree of the hypermetropia. These five types include all the possible varieties of regular astigmatism, and may be conveniently expressed by their several symbols.

In M + Am all distant objects appear confused and indistinct, but there is a certain distance at which a point is seen under the form of a line corresponding to the second focal line (f^2), and there is a second, shorter distance at which the same point is seen as a line at right angles to the former line and corresponding to the first focal line (f^1). In Am a distant point is seen as a line corresponding to the second focal line (f^2), and a point at some shorter distance is seen as a line corresponding to the first focal line (f^1). In Ah a distant point is seen as a line corresponding to one or the other of the focal lines (f^1 or f^2), according as the eye is in a state of rest or is accommodated to a degree equal to the measure of its astigmatism. In H + Ah a distant point is seen as a line corresponding to the first focal line (f^1) through the exercise of a portion of its accommodation equal to the measure of its hypermetropia (H), and it may be seen as a line corresponding to the second focal line (f^2) through the exercise of the accommodation equal to the sum of the measures of its hypermetropia (H) and its astigmatism (Ah). In mixed astigmatism (M + Ah or H + Am) the eye may accommodate to the degree necessary to focus a distant point in its second focal line (f^2), and, at some shorter distance, it may relax its accommodation, so as to focus a point in its first focal line (f^1).

In any case in which a point is seen under the form of a line, all lines at the same distance which correspond in direction to the direction of this linear image, will also be seen distinctly. Hence the visual phenomena in astigmatism may be best studied by the use of test-objects made up either of points or rows of points, or of lines or sets of parallel lines. Two such test-objects are shown in Figs. 331 and 332, as they are seen by the normal eye when accurately focussed for their distance, and as they appear to an astigmatic eye when similarly adjusted in its vertical meridian. In Fig. 331, *b*, every dot is seen elongated and blurred in the horizontal direction, so that the dots in the horizontal rows appear to run into each other, while in the vertical rows they are seen distinctly

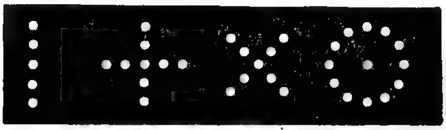


Fig. 331, *a*.

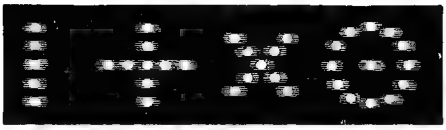


Fig. 331, *b*.

separated. Similarly the horizontal lines in Fig. 332, *b*, are seen sharply defined, while the vertical and oblique lines appear blurred.

The diagnosis of astigmatism may be made objectively, by means of the ophthalmoscope, or subjectively, by direct tests of the vision made with appropriate test-objects. In the case of young children the ophthalmoscope offers the only available method, and in many other cases it renders very valuable service by giving the first clue to the nature of the refractive defect and the direction of the meridians of greatest and least refraction. In this method of examination, the retinal vessels and the circular outline of the optic disk furnish test-objects corresponding in a general way to the dots and lines shown in Figs. 331 and 332, and the determination of the refrac-

Fig. 332, *a*.

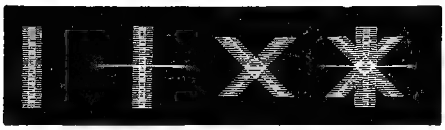


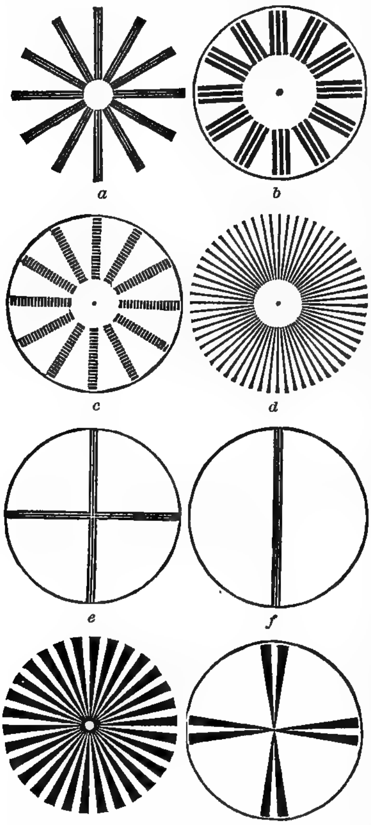
Fig. 332, *b*.

tion is made for the meridians of greatest and of least refraction, by noting the strongest convex or the weakest concave lens through which the observer can see distinctly the vessels which lie at right angles, respectively, to the direction of these meridians. In the higher grades of astigmatism the fundus of the eye presents the very characteristic picture of a confused red ground, marked by parallel streaks of a deeper red in which the double contour of a vessel is occasionally recognizable, and by a lighter spot, the optic disk, which is seen blurred and elongated in the same direction. The inspection of the details of the fundus is best made with the ophthalmoscope of Loring, in which a revolving disk, containing a series of convex and concave lenses, is mounted immediately behind the mirror. To secure a good observation it is often necessary to dilate the pupil, but it is not

* This experiment may be varied by using only the convex-spherical lens, and turning it a little obliquely to the direction of the incident pencil, the oblique position of the lens having the effect of increasing its refractive power in the plane at right angles to the line about which the lens is turned. If instead of the candle flame a very bright light is used, such as a calcium light or a beam of sunlight directed by means of a mirror through a small hole in the window shutter, the pencil will be seen lighting up the dust of the room along its entire course.

usually essential to completely paralyze the accommodation. Cocaine hydrochlorate (1 : 25) and homatropine hydrobromate (1 : 250) are convenient mydriatics for this use. Other methods of diagnosticating astigmatism by the aid of the ophthalmoscope have been proposed (see Ophthalmoscope and Optometry), but the procedure here described is the one which is generally employed.

More accurate measurements of astigmatism are made by testing the acuteness of vision, in the recognition of points and lines arranged in suitable test-diagrams similar to the test-objects shown in Figs. 331 and 332. Examples of such test-diagrams, which may be almost infinitely varied, are shown in Fig. 333, *a* to *h*. They are printed on circular cards, about nine inches in diameter, and are drawn to such a scale that the finer lines are recognizable by the normal eye at a distance of about eight metres. They are intended to be hung upon the wall, in a good light, and viewed, as distant objects, from the opposite side of the room. When an astigmatic eye is directed upon one of the diagrams made up of radiating lines or sets of lines (Fig. 333, *a* to *f*), or of narrow sectors (Fig. 333, *g* and *h*), the lines which lie in the plane of one of the principal meridians are generally distinguished more perfectly than those which lie in the planes of the other meridians. In simple myopic astigmatism (Am) the line or lines which lie in the plane of the meridian of greatest refraction are seen clearly, while those in all other meridians appear indistinct or confused. In mixed astigmatism (M + Ah, or H + Am) the lines which lie in the plane of the meridian of greatest refraction are distinguishable through the exercise of the accommodation equal to the measure of the hypermetropic portion of the anomaly (H or Ah), while the lines corresponding to all the other meridians appear confused.



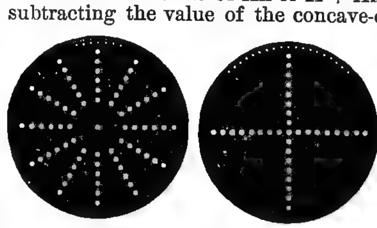
g FIG. 333. *h*

In simple hypermetropic astigmatism (Ah) the lines in the meridian of least refraction are seen clearly when the eye is in a state of accommodative rest, and these lines become confused, while those in the meridian of greatest refraction become distinct, when the accommodation is exerted to a degree equal to the measure of the astigmatism (Ah). In compound hypermetropic astigmatism (H + Ah) the lines in the former or the latter of these meridians may be distinguished through an exercise of the accommodation, equal in the one case to the measure of the hypermetropia (H), and in the other case to the sum of the measures of the hypermetropia and astigmatism (H + Ah). Only in compound myopic astigmatism (M + Am) do the lines appear confused in all the meridians, although least so in the meridian of greatest refraction, until the myopia (M) is corrected by placing a suitable concave lens in front of the eye, and the case is thus brought into the condition of simple myopic astigmatism (Am).

In the hypermetropic forms of astigmatism (Ah, and H + Ah), and also in certain cases of mixed astigmatism, the examination is rendered difficult by the unconscious efforts of the patient to recognize as many as possible of the test-lines, through the exercise of the accommodation. To overcome this difficulty it is necessary to suppress the accommodation for the time being, which may generally be accomplished by placing before the eye a convex glass of sufficient strength to correct it for vision in the meridian of greatest refraction; in other words, to bring the eye into the condition of simple myopic astigmatism (Am), by making it look through the strongest convex glass through which it can clearly distinguish the lines in any meridian. The disturbing influence of the accommodation may also be annulled by means of atropia, several times instilled, until the accommodation becomes completely paralyzed. This involves, however, a serious disturbance of vision, which may persist for many days, and also the special disadvantage of enlarging the pupil far beyond its usual diameter, and so including in the measurement a peripheral zone of the cornea, which may differ materially in curvature from the central portion, which alone is ordinarily utilized in vision.*

In the investigation of any case of ametropia by this method, we first select, by successive trials, the weakest concave glass (in M + Am) or the strongest convex glass (in M + Ah or H + Am, Ah and H + Ah) through which the lines in any meridian are clearly distinguished. If the lines in all the meridians are seen through this spherical glass with perfect distinctness, astigmatism is excluded, and the case is one of simple myopia (M), or hypermetropia (H). If the lines in only one meridian are distinctly recognized, this meridian will be that of greatest refraction (M_0), and the glass through which the lines are seen will represent the measure of the ametropia (M or H) in the meridian of least refraction. When these two elements have been determined, it only remains to ascertain the degree of astigmatism, by successive trials with concave-cylindrical glasses, until a glass is found through which (in addition to the spherical glass already chosen) the lines in both principal meridians are seen clearly. This cylindrical glass is the measure of the astigmatism.

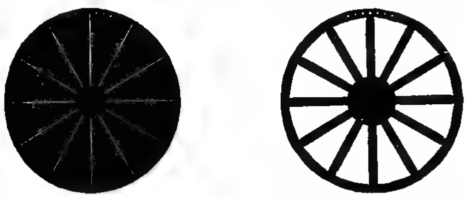
Proceeding in this manner, we obtain a formula for the eye, which is correct in form for the case of simple myopic astigmatism (Am) and of compound myopic astigmatism (M + Am), and also for most cases of mixed astigmatism (M + Ah or H + Am). In simple hypermetropic astigmatism (Ah), and in compound hypermetropic astigmatism (H + Ah), it is necessary to transpose the formula from its original form, in terms of H + Am, to the equivalent form in terms of Ah or H + Ah. This is done by subtracting the value of the concave-cylindrical lens (in dioptrics) from the value of the convex-spherical lens (also in dioptrics), taking the remainder as the measure of the hypermetropia (H) and changing the symbol Am to Ah. When H = Am, this remainder is zero, and the case is one of simple hypermetropic astigmatism (Ah). When H < Am, the remainder is a negative quantity, and its symbol is changed from H to M; the expression then becomes M + Ah, which is the alternative formula for mixed astigmatism.



a FIG. 334. *b*

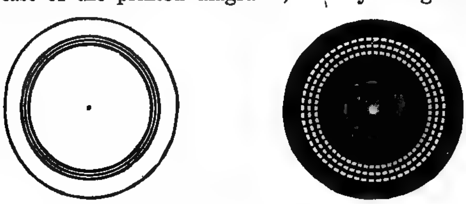
* It has been the practice of the writer to abstain from the use of atropia in the measurement of astigmatism, except in a few cases of special difficulty, and never to adopt a measurement made under full mydriasis until it has been verified or corrected by other tests, made after the pupil has returned to its normal size.

Test-objects constructed of combinations of points or dots, are best made by punching holes in a sheet of cardboard, which is to be hung in a window against a background of ground glass or of white or colored (yellow or red) tissue-paper (Fig. 334). The astigmatic eye sees each bright dot elongated in the direction of one of its principal meridians, and if the test-object is viewed through a spherical lens, selected as in the case of examination by the aid of the diagrams with radiating lines, the elongation will be in the direction of the meridian of greatest refraction (M_0). If now the attention is directed to the



a FIG. 335. b

row of dots lying in this meridian, the several dots will appear as if fused together in a bright streak, whereas in the other principal meridian (of least refraction) they will be seen perfectly distinct from each other, and can be easily counted. Transparent test-objects may also be made with radiating lines, either bright lines on a dark ground or dark lines on a bright ground (Fig. 335). Owing to the strong irradiation, the contrast between the lines in the several meridians is much more conspicuous than in the case of the printed diagrams, and by using one or



a FIG. 336. b

more thicknesses of yellow or red tissue-paper for the background of the punched cards, we may reduce the irradiation to any degree that may be found most advantageous. A useful test-object may also be made with translucent red (carmine) radii on a translucent blue (ultramarine) field, separating the two colors by narrow dark lines to prevent overlapping of the images due to the defective achromatism of the eye: the radii which lie in the plane of the ametropic meridian are seen in their proper color, while the others appear of a combination

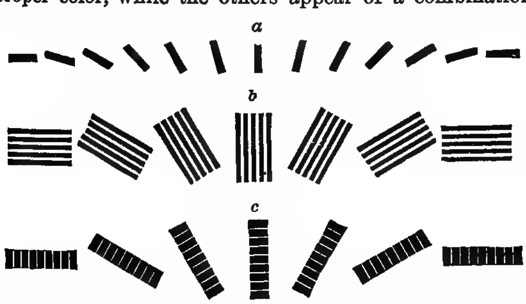


FIG. 337.

(purple) tint. Test-diagrams may be also constructed of circles in the place of radii, or of combined radii and circles (Fig. 336); or lines of different degrees of inclination may be arranged in a linear series (Fig. 337), or as in the test-letters for astigmatism of Dr. Pray (Fig. 338). Advantage may also be taken of the property of certain letters to take on confusing shapes under the influence of astigmatic refraction (Little).

A stellate arrangement of very fine lines may be used as a test for astigmatism, by placing it at or near the principal focus of the convex lens of an optometer (Burow). The best apparatus for this purpose is the binocular optometer of Javal, in which the two eyes are severally directed, with their axes parallel, upon two small figures, like watch-dials, corresponding to the two pictures on a stereoscopic slide (Fig. 339). Upon one of the dials are engraved the hours, and the star of fine lines; besides these there are a number of circles and lines common to both dials, for the purpose of securing perfect binoc-

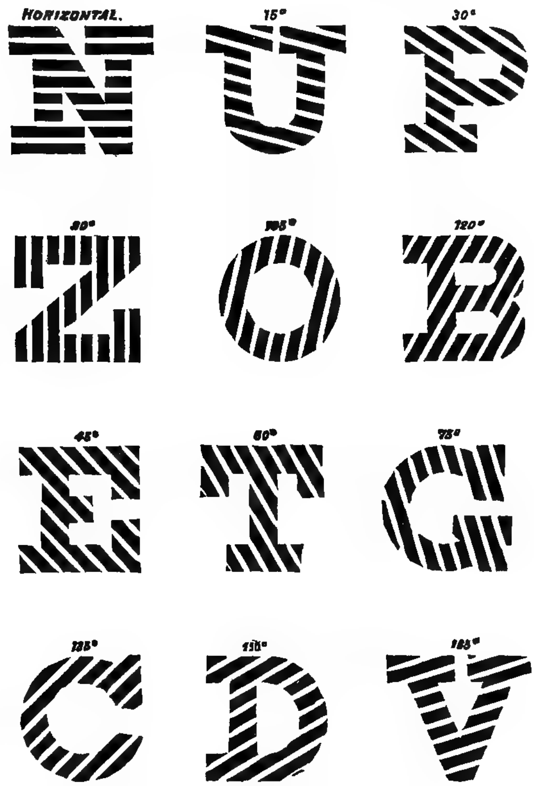


FIG. 338.

ular fusion of the two pictures. The radiating lines are thus viewed by only one of the eyes, while the other is fixed upon the second dial. The card upon which the dials are printed is placed in the optometer (or in a stereoscope fitted with a sliding holder), at a distance from the lenses well within their principal focus, and is then moved slowly away until all the radii but those in one meridian become indistinct; this meridian corresponds to the ocu-

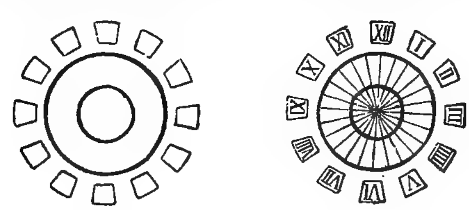


FIG. 339.

lar meridian of greatest refraction (M_0), and the measure of the refraction for this meridian is the difference between the power of the convex lens (in dioptrics) and that of a lens (also in dioptrics) having a focal length equal to the greatest distance at which the line in question is distinctly seen. The measure of the astigmatism is obtained by successive trials with concave-cylindrical lenses, placed in front of the lens of the optometer (or stereoscope), until

a glass is found through which all the radii are seen clearly defined. Having measured one of the eyes in the manner described, the card may be inverted (or exchanged for another with transposed dials), and the other eye tested in its turn.

The *stenopæic apparatus*, which is simply a thin plate of blackened metal perforated by a narrow slit, may be used to shut out from the eye all rays except those which lie in the plane of the meridian of the slit. In this way it is possible to measure in succession the refraction in the several ocular meridians by the use of spherical glasses. The stenopæic slit is often very useful in the first approximate diagnosis of astigmatism, but the method is inferior in accuracy to those in which cylindrical lenses are employed.

A method of determining the degree of ametropia, based on the experiment of Scheiner (1619), has been elaborated by Thomson (*Am. Jour. Med. Sciences*, January, 1870). Let L (Fig. 340) represent a candle-flame or small gas-jet, five metres distant from the eye, and A B a small opaque screen, perforated by two pin-holes four millimetres between centres. The two small pencils, L A and L B, which are parts of the pencil A L B, intersect, after refraction, at the focus of the pencil, which in the emmetropic eye is at the central fovea of the retina, and the candle-flame is seen single. In hypermetropia the two small pencils are cut by the retina before their intersection, at $h\,h'$, and in myopia after their intersection at $m\,m'$, and in either case the flame is seen doubled. If the hole A is covered by a bit of red glass, one of the images will appear of a red color, and this red image will, in accordance with the law of projection, be seen upon the same side with the hole A in myopia, and upon the opposite side in hypermetropia. The distance between the two images is in direct proportion to the degree of the ametropia, and is measured by holding a second lighted candle

FIG. 340.

near the fixed light, and moving it until one of its images coincides with one of the images of the fixed flame, and but three images of the flame are seen. The distance of the two candles from each other, in centimetres, is the measure of the ametropia in half-dioptrics. To utilize this method in the measurement of astigmatism, the screen is rotated in its own plane, so that the two holes are brought to coincide successively with different ocular meridians: the two meridians at right angles to each other, in which the two images appear at the maximum and minimum distance apart, are the principal meridians of greatest and least ametropia respectively. This method is often of very easy application, and is very accurate in its results; it has, besides, the advantage of not depending upon the recognition of test-lines or test-letters.

In practice, the attention is ordinarily first attracted to astigmatism by the fact that vision is notably defective, as tried by the test-letters of Snellen (see Optometry), and that it cannot be raised to the normal by any spherical lens, whether concave or convex. Moreover, the astigmatic eye does not readily settle upon the best of several spherical lenses, any one of which may materially improve vision, although no one of them is perfectly satisfactory. In such cases, the addition of a weak cylindrical lens may, in some one position of its axis, still further improve the recognition of the test-letters, and, by following up this clue, an accurate correction may often be reached without further trouble. In other cases, the first trials with cylindrical glasses do not yield a positive result, and it may be found more convenient to substitute the intelligent and trained observation of the surgeon for the untrained and often inaccurate observation of the patient. We therefore look into the eye with the ophthalmoscope, and inspect the details of the fundus, and especially the different branches of the retinal artery and vein, in the erect image. Then, turning the disk of the ophthalmoscope, we bring the several lenses successively into position behind the hole in the mirror, until we have found the strongest convex or the weakest concave lens through which any one of the blood-vessels in the retina is distinctly visible. Having thus learned the direction of the meridians of greatest and least refraction, and also approximately measured the refraction in the latter, we may extend the observation to the retinal vessels which lie in the meridian at right angles to that first observed, and so arrive at an approximate estimate of the degree of the astigmatism. If we are compelled to rely wholly on measurements made by the aid of the ophthalmoscope, the observation should be repeated after dilatation of the pupil, but in other cases we adopt, provisionally, the result obtained and try to improve upon it by subjective tests with test-letters, test-diagrams of radiating lines, etc. The method of Thomson may also be used, both to obtain a clue to the nature of the refractive defect and to make the measurements necessary for prescribing glasses.

The correction of astigmatism is by wearing convex- or concave-cylindrical or spherico-cylindrical glasses, so mounted that the axis of the cylindrical surface shall lie in the plane of the ocular meridian of greatest refraction (M_o) when the cylindrical surface is convex, or in the meridian of least refraction (at right angles to M_o) when the cylindrical surface is concave. Cylindrical lenses are ordinarily manufactured in large quantities by machinery, and are sold in the form of plano-cylindrical disks (convex and concave); any spherical surface which may be required is ground to order by the optician, upon the plane side of the disk. Lenses may also be ground with two unequal cylindrical surfaces, with crossed axes, but such lenses do not differ in effect from those in which a spherical and a cylindrical surface are combined.

As the ordinary spherical glasses, convex or concave, worn in hypermetropia or myopia, have the incidental effect of increasing or diminishing the apparent size of objects, so the effect of a convex- or concave-cylindrical glass, worn for the correction of astigmatism, is to increase or diminish the apparent magnitude of all objects, in the direction at right angles to its axis. Thus a circle is made to appear as a somewhat elongated or as a somewhat compressed ellipse, a square as an elongated or shortened parallelogram, etc. This distortion, which is in proportion to the strength of the cylindrical glass required to correct the astigmatism, may give rise to some temporary annoyance, or may even be a source of curious stereoscopic phenomena; errors of judgment from this cause are, however, speedily corrected, as the patient becomes accustomed to the new conditions.

As a consequence of the impairment of the acuteness of vision, which in the higher grades of astigmatism is often very great, the astigmatic person may be compelled to hold his book quite near to the eyes in order to distinguish the smaller sizes of print. In other cases, the effort to improve the recognition of special details of the object, through rapid changes in the accommodation, may be also a cause of fatigue. Particular forms of astigmatism may, therefore, contribute materially to the development of asthenopia, either accommodative or muscular (see Asthenopia), of excessive accommodative tension and progressive myopia (see Accommodation and Refraction, Pathology; Myopia), or of convergent or divergent strabismus (see Strabismus).

IRREGULAR ASTIGMATISM.—Under this title Donders has included all visual defects which depend upon a difference in refractive power in different parts of the same ocular meridian. It includes, therefore, the aberration in the eye which is the analogue of spherical aberration in an ordinary lens, also the confusion of vision caused by irregularity in the general form or in the surface of the cornea, and, especially, the phenomenon of multiple vision with a single eye (*polyopia monophthalmica*) due to inequality in the refraction of the crystalline lens in its different sectors, and in different parts of the same sector.

Some degree of irregular astigmatism is present in every eye, and must, therefore, be considered as *normal*. Under this head falls the irregular refraction which de-

pends upon the partial scattering of the rays of light in passing through the crystalline lens. If we prick a very small hole, with the point of a fine needle, in a card, and, holding it a little within the anterior focus of the eye (14.8 mm. = ⅝ inch in front of the cornea), look through the hole at a bright light, the shadow of the pupillary opening and of the central portion of the crystalline lens will be thrown upon the retina, and will be seen as delineated in Fig. 341 (Donders). If now we move

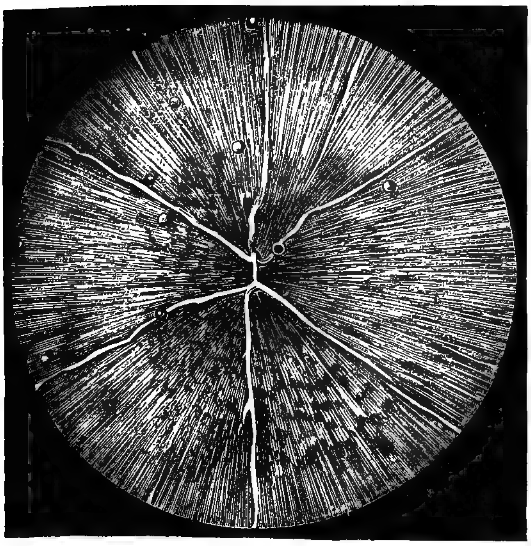


FIG. 341.

the card slowly away from the eye, this picture will change gradually to the familiar figure which we call a star, and which we see when we look at a star in the heavens, or at a distant point of light. If, instead of a luminous point, we look at a minute speck of white pigment on an intensely black ground, the speck will appear multiple, as in Fig. 342 (Helmholtz).

If we look, with a single eye, at a disk made up of concentric circles, as in Fig. 343 (after Helmholtz), the circles will appear wavy and confused in particular sectors of the disk, and also abruptly bent or broken along the radii which separate one sector from another. From these experiments it is evident that the eye does not focus a point sharply upon its retina, but rather as a small group of points, each one of which is also somewhat expanded and distorted, or, in the case of a bright point, as a star-shaped figure, made up of a number of points more or less completely fused together, and rendered still more complex by innumerable fine radiating lines. Thus, a brilliant fixed star, or planet, is seen as a very conspicuous object, whereas the image of a fixed star in the most perfect and the most powerful telescope is but an intensely bright point of inappreciable diameter. A white dot, line, or letter, on a black ground, is seen similarly expanded, and is, therefore, visible at a greater distance than a black object of the same size upon a white ground; but, on the other hand, the shape of the black object may often be recognized at a greater distance than that of the bright object. This phenomenon is called *irradiation*. The phenomena of normal irregular astigmatism are complicated, to some extent, by the aberration of curvature, in so far as the curves of the cornea and of the crystalline lens vary from the theoretically perfect curvatures requisite for the refraction of incident rays to a single focus, and also by the slight inequality of curvature in different meridians, which is demonstrable in almost every eye, and which must, therefore, be considered as *normal regular astigmatism*. Hence the retinal image of a star is actually seen a little more expanded than it would be as a result of the scattering of the rays of light in traversing the crystalline lens, and, in the presence of low grades of regular astigmatism, the star is also seen more or less elongated.

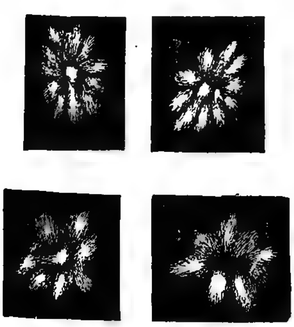


FIG. 342.

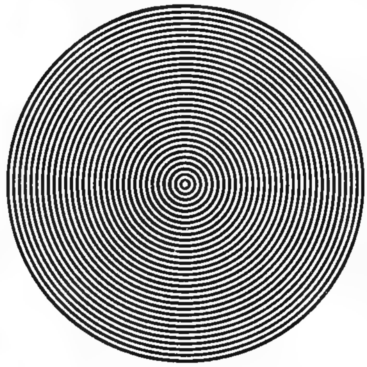


FIG. 343.

Abnormal irregular astigmatism attains perhaps its highest grade in conical cornea (*staphyloma pellucidum*), in which affection it may be a source of very great confusion of vision. Inflammatory processes in the cornea may lead to softening and consequent irregular distention of that tissue; and changes of curvature, both total and partial, may follow the cicatrization of corneal wounds or ulcers. In all these cases the disturbance of vision may be in part resolvable into regular astigmatism, and sight may then be materially improved by wearing appropriate cylindrical glasses; in other cases the definition of objects is much improved by looking through a small hole or narrow slit punched in a blackened card; and, in rare instances, it may be justifiable to attempt to change the position of the pupil by the operation of *iriddesis* (Critchett).

Abnormal irregular astigmatism, with multiple vision, is often observed as a result of changes in the crystalline lens, incident to the incipient stages of cataract; myopic refraction may also be developed, at the same time, through an increase in the general curvature of the lens surfaces. *John Green.*

ASTRINGENTS. Agents which cause contraction of the tissues with which they come in contact. The principal drugs of this class are: Tannic and gallic acids and the substances containing them, alum, alcohol, dilute acids, cocaine, acetate of lead, perchloride and sulphate of iron, nitrate of silver, the sulphates of copper and zinc, subnitrate of bismuth, and other of the metallic salts.

The astringents are employed both externally and internally, but their action is always local; and although many of them exert also a systemic effect, they do so not by virtue of their astringency, but because of other properties which they possess. Thus, perchloride of iron is a tonic, but it shares this property with other preparations of iron, some of which are but little or not at all astringent. The substances of this class are used to check unhealthy secretion from the skin, mucous membranes, or ulcerated surfaces. In local hyperidrosis, applications of the dilute mineral acids, vinegar, alcohol, or alum solutions are often of great service, and even when there is general excessive sweating, sponging the body with acidulated water or dilute alcohol is a valuable adjunct to other remedies. Solutions of the metallic salts, and preparations containing tannin, are extensively employed in catarrhs of the mucous membranes during the subacute or chronic stage, but are often harmful rather than beneficial in acute inflammation before the establishment of secretion. In passive diarrhœa, the astringents in combination with opium are of great service, but are of doubtful utility in acute enteritis and dysentery. They possess valuable styptic properties when locally applied,

but their power to control hæmorrhages of distant organs when internally administered is, to say the least, doubtful, although they are frequently given for this object. The astringents are further employed to harden and restore tone to relaxed tissues. When applied to ulcerated surfaces, they not only squeeze out the spongy granulations and diminish the secretion, but by coagulating the pus, cause the formation of a pellicle by which the abraded surface is protected from the atmosphere. Parts exposed to external irritating influences and liable to excoriation, may be hardened by bathing with alcohol or solutions containing tannin.

Thomas L. Stedman.

ATAVISM (*atavus*, a great-grandfather), the tendency, in animal and in vegetable life, to inherit biological pre-existences, and to return to a primitive type progressively altered. It is by virtue of this tendency that living organisms inherit peculiarities from their remote ancestry which their immediate parents did not present.

Atavism is not to be confounded with ordinary inheritance or heredity. In the latter, the tendency of nature is to reproduce in the offspring certain peculiarities of the parental organization; under the influence of atavism, the offspring may take the traits and characters of the primitive form with no resemblance either to father or grandfather, but to ancestors more remote. Atavism should be distinguished from the variations, teratological, pathological, or toxonomic, that interrupt the normal succession of hereditary phenomena. Nearly synonymous is the term *survival*, used by Tylor to signify a superstitious remainder or residuum of bygone ages, and the Darwinian expression *reversion*, to indicate the occasional or individual appearance of traits accumulated by heredity and handed down from remote ancestry. Reversion is also used to signify the actual returning of a variety or species to such remotely descended traits. This is instanced in the tendency of animals long domesticated, when they become feral, to revert to the pristine form. As a case in point, we may mention the wild horses of Montana, which are such a source of annoyance to stock-raisers in enticing away tame horses, that their slaughter is made an object of hunting parties. That the notion of atavism has prevailed for some time, it is only necessary to allude to the biblical version regarding the visitation of the sins of the father upon the children of the third and fourth generations. In the sixteenth century, Montaigne noticed these strange transmisssions, and wondered how the little drop of semen from which we are produced, bears not only the impressions of the bodily form, but a likeness of thought and inclination through a progress so hap-hazard and so irregular, that the great-grandson shall resemble the great-grandfather, and the nephew, the uncle. Darwin, speaking of the injurious characters that tend to reappear through reversion, mentions the blackness in sheep, and with mankind some of the worst dispositions which occasionally, without any assignable cause, make their appearance in families.

The atavic influence has been well traced in the laws that determine the evolution and culture of a plant, and its reversion to the wild or uncultivated state.

To illustrate this, experiments have been made with the little flower, familiarly known as the *bluet*, and with Indian corn. Broca continued these experiments for eight years. He found, among a bed of bluets sowed with seed collected from an open field, the greater part of the flowers to be blue, but some bore violet flowers, and even some a little reddish. The seeds of these reddish flowers were sowed and collected the following year. Of a hundred flowers, about two-thirds of them were a fine blue; others presented various shades, ranging from blue to violet, from violet to red, and even to rose. The lightest-colored of these flowers were preserved, and used the following year to sow another border. This time the number of flowers entirely blue was little less than half; the greater part being violet or red. There were many red, and some of a red so light as almost to pass for white. It thus appears probable that, in making a methodical selection from each generation of the lightest-colored flowers, the conditions are favorable to obtain a fixed race of *bluets* quite *white*.

The influence of atavism is further shown in maize or Indian corn, of which there are two varieties, or rather two distinct races, the light and the brown. That they are more than simple varieties is shown by the fact that we can never obtain by culture intermediary shades. Artificial fecundation being very easy upon this androgynous plant, permits us to obtain variegated ears, which bear at the same time light grains and brown ones, as we see in what is known as "pop-corn;" but each grain belongs entirely to one or the other race. A farmer having accidentally discovered an ear of corn entirely brown, called the attention of Broca to this extraordinary circumstance. He considered it a natural variety, produced spontaneously, perhaps, under the influence of an atavism going back to a great number of generations. The grains of this ear having been planted, gave sixty-nine ears, thirty-five of which were light and thirty-four brown. Repeated experiments gave equal results. A fact worth noting on this point is that all the ears of the same stalk were of the same color.

Atavism is shown in the action of the seminal principle that passes secretly through a generation, as is seen in certain insects, the wood-louse for instance, where a single fecundation answers for nine generations of insects, all of whom are born prolific, and procreate without the help of the male. In this case, the individual of the ninth generation has received his life, his form, and his instincts from an eighth-grandfather, a long time disappeared.

The same law that governs the vital continuity in the foregoing instances, applies to the lower animals and to mankind. Among dog-fanciers and stock-raisers atavism is a matter of much concern, for they have need to exercise great care, in the multiplication of these animals, to choose as reproducers only those whose grandfathers have no transmissible defect. On this point, the experiment mentioned by Darwin may be cited. The Earl of Powis caused some domesticated hump-backed cattle to be crossed by the wild species from India, with the result, not of producing a medium grade of characteristics, but of a marked reversion to the ancient. Unhappily for man, atavistic antecedents are not taken into account in the matter of union of the sexes. Like other animals, it is in virtue of atavism that man often reproduces the traits of his grandparents. According to Darwin, characters occasionally make their reappearance in him which we have reason to believe were possessed by his early progenitors. People marry and the offspring frequently resemble the grandparents, not only morphologically, but in temperament, diatheses, and even their diseases. It is well known that portrait galleries and the monuments of churches in Europe, help to trace the source from which some long-lost type of feature has been derived; and the reappearance of the Bourbon nose in France is a matter of common knowledge.

The occasional appearance of a child covered with hair is regarded by many as a fact of very old atavism. The hairy men of Japan, the Aïnos, are also believed to be reversions to some ancestral form, and it is argued by some that the anthropoid apes may be the descendants of apelike men. Doubtless some of our readers who have lately visited the Paris Hippodrome remember that remarkable anthropological phenomenon (*l'Homme Ours*), a pilose Russian, whose peculiarities are believed to be due to a phenomenon of reversion to the characters of a very ancient lost race. It is thought by those who have given the matter attention, that many races of men have lived before the present races without sending representatives of their types down to us; but they have not disappeared without the blood of several among them being transmitted by infinitesimal dilutions down to the present races.

An attempt to point out with precision the laws of atavism results in the statement that every organized being that is born is the product of two forces, one of which is the resultant of his complete genealogical tree, from the first origin of the organic branch from which he springs,

and the other is furnished by all the circumstances that have acted upon the individual himself during all the duration of his development. It is further asserted that when men or animals manifest impulses of an excitable character, and exhibit pleasures and sympathies, and pains and antipathies that seem to be out of relation to their culture and personal experiences, or to the culture of the family or the race, whether in dreams or when waking, the source of these must be found in long-past or ancestral memories reproduced according to the law of reversion.

Not the least curious of the modes of manifestation of atavism is in connection with memory. According to Galton, the celebrated English Hellenist, Dr. Porson, whose memory was surprising for its extent and fidelity, transmitted this peculiarity to one of his grandchildren, Lady Hester Stanhope, who claims to have inherited her grandfather's memory. Assuming that certain antecedent synesies have been ancestrally realized in time and space, the reversion to them may become the starting-point of a new evolution. The capacity of reproduction or re-evolution of the transmitted antecedent synesies or substrata is ancestral memory. The faculties that preside over the representative signs of ideas, it is said, are also subject to the law of correlative evolution and reversion which is manifested both in health and disease. Scriptorial atavism is witnessed in the reversion to ancestral styles of writing; and in the speech it is noticed in the reversion to ancestral or racial pronunciation of letters and words. In aphasia the patient often reverts to the language of childhood, which is his only language, and, like some races of savages, he is unable to pronounce labials. A further pathological reversion is seen in dreams, that are in fact nothing more nor less than abnormal reminiscences and reproductions. The pleasures and pains of memory may be transmitted also as substrata from remote ancestors.

States of consciousness, owing to ancestral reversion, are shown by various facts. It has been noticed that in a menagerie the straw for bedding lions and tigers could not be used for horses, because the odor terrified them when it was brought into the stable. Yet many generations of horses have passed away since they were troubled by these beasts. Sir David Brewster's fear of drowning, which haunted the minds of more than one of his descendants, is also cited as an instance.

Reversion to synesies is shown during special conditions of the brain-tissue, such as characterize sleep and dreaming, somnambulism, and insanity. Certain vain pleasurable and painful states are likewise due to ancestral reversions. The keen pleasure afforded by the sight of mountains and hills; many prejudices, antipathies, and æsthetic sentiments, are due to ancestral substrata. The writer has often noticed these conditions in himself, which can be accounted for in no other way, in strolling about the streets of Edinboro, or in listening to the bagpipes, in climbing the heathery Scotch hills or the misty hills of Alaska, sights and sounds that doubtless afforded similar pleasure to his Caledonian ancestry.

Emotional reversion is noticed in those cases of cerebral disease in which the semeiotic or sign-making tissues are involved, and speech or the other modes of expression are affected. Immoral dreaming in persons whose life is above reproach during waking hours, is cited as a further instance of a morbid emotional reversion.

There are also reversions, due to defective evolution and nutrition that can be traced beyond immediate ancestors, to substrata of the race acquired during savage or primitive life in long-distant ages. An instance of this occurs where the conduct is that of uncivilized man. In theroid idiots, or imbecile reversion to brute-like character of form, there are no signs of morphological reversion, but the dominant aberrations are theroid. The permanence of a substratum of savage life is seen in our large cities among the vicious classes, who are to all intents and purposes savages in everything but speech, dress, and name.

Of psychological interest at the present time are the reversions to ancestral modes of thought in France, where there is a reversion to the ancient doctrines of metempsychosis, and of the evolution and transmission of souls.

In human pathology the reappearance of morbid traits existing in ancestors, but not in immediate parents, can be maintained by cited cases; and the influences of atavism in the hereditary transmission of disease, can be traced for four, five, seven, or, in fact, an unlimited number of generations.

The principal diseases and defects in which the influence of atavism has been traced, are color-blindness, the hæmorrhagic diathesis, pseudo-hypertrophic muscular paralysis with its allied diseases, and a large number of the neuroses.

Among the old and well-known cases of color-blindness is that reported by Dr. Earle, in which, in addition to the usual limitation by atavism to alternate generations, there was evidence of transmission from a great-grandfather to two great-grandsons, without the development of the peculiarity in the intermediate transmitters of the defect. There is another more recently recorded case of the same kind in which two generations were skipped over, the transmission being effected through two females in the second generation, and thence onward through three females in the third generation, to seven great-grandsons in the fourth generation.

Such extension is still more frequently observed in cases of hæmatophilia, or the hæmorrhagic diathesis. In fact, its most important mode of propagation is not so much by the bleeders themselves, as by their non-bleeder brothers and sisters. In the literature of hæmatophilia there are numerous instances of its indirect transmission. The "Appleton-Brown bleeder family" is known to American physicians. Investigation shows the "Tenna bleeders" in Switzerland to be descended from an extremely remote ancestor of the name of Walther. The influence of atavism is distinctly traced, in the insanity and blindness of George III., to his remote ancestor, Duke William, eight generations back. Cases of deaf-mutism have been known to descend from male ancestors five generations back, and the atavic transmission of a family defect to be handed down in a direct male line from a deaf-mute great-grandfather to a deaf-mute great-grandson.

Dr. Matheson, of Ontario, who has examined the histories of six hundred and sixty-one mute children, states that he is unable to find that any of the parents were, or are, deaf and dumb persons. A few of their grandparents, however, were mutes.

The instability of insanity may pass on through one or more generations without its being developed. A case is related where a man had two wives, and by each wife one child—a boy by one, and a girl by the other; yet both these children were alike nervously unstable, the father's mother having been a lunatic.

Other diseases, such as scrofula, consumption, and the diatheses, and even congenital or moral defects, the so-called criminality and forms of wickedness, may sometimes disappear for several generations, and crop out in a manner evidently due to atavism. This is instanced in the history of prostitution, in the issues of courtesan mothers, and it is not necessary to refer to the Messalinas, Poppæas, and Julias of antiquity.

Hypospadias may be developed by what is termed "indirect atavism." On this point Dr. Lingard remarks that all breeders of cattle and other animals are familiar with this fact of the females throwing back—that is, reproducing, after impregnation by a second male, the peculiarities of some other male by whom they had been previously impregnated. That this is not impossible in the human female, he thinks, is proved by the following case: The third of six hypospadians died a few years after the birth of his three sons. His widow within eighteen months contracted a second marriage, the husband, in this instance, not being a hypospadian, and having no history of any such defect in his family. By this marriage she had four sons, all hypospadians. Two of these hypospadic sons begat hypospadians in their turn. But one of these sons had three boys, without any deficiency, although the eldest boy was a hypospadian.

It is to be regretted, in the interests of science, that families are averse to keeping a history of their diseases. It is to be hoped that Mr. Francis Galton's recent efforts in this direction may be successful. Sir Henry Holland mentions an instance in which four out of five of a family of children became blind at the age of twelve; the only record of any preceding occurrence was an ancient tombstone, the figures and inscriptions on which showed that a mother and her children, members of two remote generations of the same family, had also been blind.

The manner in which these biological pre-existences are transmitted, though interrupted or latent, and yet return to visit the children of other generations; the causes of the phenomena that lead to a complete return to a certain race or to the progressive diminution and final disappearance of types, and the number of generations required to extinguish the atavic influence of an anterior race, are questions that present themselves continually in the study of human races whose purity has been altered by intermixtures, or whose character has been modified by other causes.

In medicine atavism is something more than a simple object of curiosity, or a barren ideality; and its practical application should be of the greatest moment to those about to engage in the most important of the affairs of life (love affairs), because they decide the make-up of the next generations. Persons contemplating marriage, and having the welfare of their offspring at heart, would do well to inquire into the atavistic antecedents of each side. Among other things, the inquiry may lead to the inference that the assertion of the Irish gentleman, who declared sterility to be hereditary in his family, is not so absurd after all, when looked at from the atavistic point of view. (See also TERATOLOGY.) *Irving C. Rosse.*

ATELECTASIS. Synon.: Apneumatosis; Collapse of Lung. The term *atelectasis* (ἀτελής, imperfect, and ἔκτασις, dilatation) is used to designate all non-inflammatory conditions, congenital or acquired, by which either the whole or sharply defined portions of the lungs are undistended by air.

In some new-born babies, more or less extensive areas of the lungs are unexpanded by the forcible entrance of air into the alveoli. This condition, which is normal in fœtal life, becomes pathological when it continues after birth, and is named *congenital atelectasis.*

In other cases, although the respiratory functions have been thoroughly established, collapse is induced as a consequence of some mechanical impediment to the movement of air through the bronchi, and a tract of lung of variable extent becomes again condensed and airless, as in the fœtal state. This is called *acquired atelectasis* or *collapse of the lung.*

Atelectasis is comparatively rare in adults, but is quite common in infancy and childhood, especially during the first few months of life. It is stated that about twenty-five per cent. of the total mortality in infants is attributable to this cause. The liability to the occurrence of pulmonary collapse adds gravity to all diseases, but especially to those of the respiratory organs at this period of life.

ETIOLOGY.—Congenital atelectasis is not commonly due to any vice or disease of the pulmonary organs, but is produced by any condition which prevents the prompt and efficient establishing of the function of respiration after birth. It may be the result of causes which have been in operation during the intra-uterine life of the child, or which have originated during or immediately succeeding birth. Physical weakness, premature birth, placental separation, compression of the cord, protracted labor, and kindred conditions are common causes of atelectasis. It is also not infrequently due to plugging of the bronchioles by liquor amnii and mucus, sucked in by efforts at respiration before the head has cleared the maternal passages. Intracranial effusions pressing upon the pneumogastric, the result of severe protracted or instrumental deliveries, may be placed among the rarer causes of this affection in the new-born.

Acquired atelectasis is always secondary to some disease or accident which interferes mechanically with the access of air to the lung-cells. In the vast majority of instances this impediment is the presence of mucus in the bronchial tubes, the effect of an acute or chronic bronchial catarrh, and collapse is therefore a frequent complication of those diseases, like pertussis and measles, in which bronchitis is a part of the natural history.

Whenever one or more terminal bronchioles are occluded by viscid mucus and swelling of the mucosa, the collapse of that portion of the lung, fed by the obstructed tube, inevitably takes place as soon as the imprisoned air is expelled or absorbed.

Weakness of the inspiratory muscles, and the consequent inability to overcome the obstacles in the tubes, is a powerful auxiliary factor in bringing about collapse, and hence any condition which decreases the physical vigor of the child strongly predisposes to this accident. It is, therefore, a common malady among those enfeebled by a bad inheritance, chronic and wasting diseases, or unsanitary surroundings. Rickets also plays an important rôle in the causation, associated as it is with softening of the ribs and narrowing of the thorax.

External pressure may render a lung, or any portion of it, airless (*atelectasis from compression*). Intrathoracic growths or exudations, spinal deformities, and upward displacement of the diaphragm by abdominal tumors or effusions, may cause collapse of such portions of the lung as are subjected to pressure.

MORBID ANATOMY.—The collapse may involve considerable areas of the lung (*diffuse atelectasis*), or it may be limited to small and scattered patches (*lobular atelectasis*). Both varieties are found in the congenital and acquired disease, but in the former the lesion usually involves larger tracts of tissue, the half, or even the whole, of one lobe; and is most frequently observed in the posterior and inferior portions of the lungs, in the tongue-shaped projections, and the apices; while, in acquired atelectasis, the patches are oftener limited to isolated lobules or groups of lobules, and are more widely disseminated through the parenchyma of both lungs.

The collapsed portions are depressed below the general surface of the lung, feel tough and dense, like soft leather, and are of a dark-blue or steel color. They are airless, do not crepitate upon pressure, and sink readily when thrown into water. When they are incised, the section is smooth, non-granular, and, if scraped, exudes a small quantity of bloody serum. After death, if the lesion is recent, the atelectatic portions can be readily inflated through the bronchus, and instantly assume the color and qualities of normal lung; but after some time has elapsed, they undergo changes which destroy their dilatability, and eventually end in the total disappearance of the vesicular structure. The pleura is always normal in uncomplicated cases.

When a considerable tract of lung is disabled, important changes ensue in the unaffected tissues and also in the organs of circulation. Pulmonary emphysema is a common sequel. The impediment to the movement of the blood through the lungs results in stasis in the pulmonary artery and the entire venous system, and leads to hæmorrhagic infarctions and œdema of the unaffected lung-tissue. The same condition also tends to prevent, in congenital cases, the closure of the fœtal channels of circulation, especially the foramen ovale.

SYMPTOMS AND COURSE.—The symptoms of atelectasis are chiefly those of "inefficient breathing and incomplete decarbonization of the blood." They exhibit varying degrees of severity in proportion to the rapidity of development and the amount of tissue involved. When the collapse is limited to scattered lobules, the symptoms are by no means marked or distinctive. But on the other hand, if it be so extensive as to suddenly arrest the function of a large part of both lungs, death may take place almost instantly. This occasionally occurs in whooping-cough or capillary bronchitis, affecting feeble, young children.

The symptoms of congenital atelectasis are usually present from birth. In a large majority of instances, respiration is established with difficulty and is notably

inefficient, but occasionally the child, although less vigorous than usual, exhibits no serious lung symptoms for some days or weeks after birth.

The literature of the subject furnishes numerous examples of children who have lived for several weeks, with a considerable portion of the lung—even an entire lobe—atelectatic, and so altered in structure as to be incapable of inflation after death.

Perhaps the most noted case is the one reported by Dr. Ryan (*London Lancet*, vol. i., 1868). A child, aged five weeks and in good condition, died suddenly. At the coroner's inquest, both lungs were found shrunken, inelastic, non-crepitant on pressure, and presenting in every particular the usual appearances of fœtal lung. They sank in water, and when they were cut into many pieces no portion of them floated. The microscope showed an absence of cellular structure.

The breathing is fast and shallow. The child lies quietly without attempting muscular movements, and his whole demeanor indicates lack of vigor. Most of the time is passed in sleep. The cry is not loud and strong, but is a piteous moan or mere whimper, and, at times, almost inaudible. The child nurses feebly or not at all. The surface, especially the face and finger-tips, become cyanotic and the extremities cold. The temperature is normal or subnormal, and the pulse feeble and rapid. The fontanelle is depressed.

In the unfavorable cases, these symptoms become more pronounced, and muscular twitchings foreshadow the coma or convulsions which so often immediately precede the fatal termination. It is not at all uncommon for still-born children who have been resuscitated with difficulty, perhaps by the prolonged use of artificial respiration, to die suddenly after a feeble existence of a few hours or, at most, a day or two. In many of these cases, even when the breathing has been apparently thoroughly established and the cries fairly strong, the post-mortem examinations have shown that only very limited portions of the lungs had been inflated. The autopsy also usually reveals a patulous foramen ovale and thrombosis of the cerebral sinuses.

Acquired atelectasis is always a secondary affection, and the symptomatology is largely influenced by the antecedent disease. As previously stated, it almost invariably occurs as a complication of primary bronchitis, or of one of those specific diseases of which bronchial catarrh is an essential element. When collapse of a considerable area of lung occurs in the course of a pulmonary catarrh, the symptoms at once assume a graver physiognomy. The breathing is more hurried, very shallow, and altered in rhythm; the respirations sometimes number from seventy to eighty in the minute. The child grows more restless, the lips become cyanosed and the extremities cold, and the whole appearance indicates profound depression. The temperature falls below normal. The nares dilate widely with each inspiration. The suprasternal depression, and the deep sulcus around the base of the chest, which forms with every inspiration, attest the physical difficulty of getting sufficient air into the lungs. When these symptoms are present, unless the obstruction in the bronchial tubes is promptly removed, permitting the free access of air to the closed vesicles, the child sinks into a state of stupor, and dies asphyxiated or in convulsions. Such severe symptoms are, however, exceptional. In most cases, the collapse only involves scattered lobules, and is indicated by symptoms similar to those just enumerated, but less violent.

The physical signs of atelectasis vary with the extent of the lesion. If several contiguous lobules, or the greater part of a lobe is affected, so as to cause consolidation of a considerable area, the physical signs are pronounced; but when, as happens in a fair proportion of the cases, the collapsed patches are disseminated through both lungs and vary in size from a pea to a filbert, each consisting of one or more lobules separated by a network of normal cells, the physical signs are necessarily negative.

However, the very absence of signs will assist in the diagnosis. For example, if in the progress of a mild bronchitis, without a corresponding increase in fever, grave symptoms suddenly arise—the dyspnœa, lividity, and general distress being greatly aggravated—and physical interrogation of the chest reveals no solidification of the lungs, the occurrence of lobular collapse offers the only satisfactory explanation of the sudden change.

When present, the physical signs are those of consolidated lung. The sonority of the chest is diminished over the affected spots, but the dulness has a marked tympanitic quality owing to the proximity of normal lung, and especially if emphysematous patches surround the collapsed lobules. The normal breathing sounds are absent, and may be replaced by bronchial respiration and bronchophony. Vocal resonance is increased, and, in acquired atelectasis, abundant mucous râles are audible over the entire chest. A very important and characteristic feature of atelectasis is the suddenness with which the physical signs are changed. Occasionally, during an examination, dulness and bronchial breathing will be replaced by normal resonance and vesicular murmur; or within a brief period, abnormal sounds may appear and disappear in different portions of the lungs. This can happen in no other pulmonary disease, and depends upon the closing of the bronchi by plugs of mucus and their speedy removal by forced expiration in coughing, crying, etc.

Diagnosis.—The recognition of congenital atelectasis, if extensive enough to give rise to symptoms, is comparatively easy. But the acquired form is always associated with other morbid conditions which render the diagnosis difficult and sometimes impossible.

Capillary bronchitis, catarrhal pneumonia, and lobar pneumonia are the only diseases for which collapse is liable to be mistaken. Catarrhal pneumonia is rarely developed except in portions of the lung already collapsed, and hence, cannot be differentiated by physical signs alone. Diffuse atelectasis differs from lobar pneumonia in the absence of fever, the percussion note is more tympanitic, bronchial respiration is less marked, and the crepitant râle is absent. The suddenness with which the physical signs are manifested and reach their full development in collapse, is an important diagnostic point. If in the course of a bronchial catarrh, symptoms of considerable severity suddenly supervene, such as rapid and shallow breathing, duskiness of the face, faint cough and feeble cry, with little or no increase in fever, the nature of the attack can scarcely be doubted. If, along with these symptoms, the physical evidence of solidified lung is present, the chain of evidence is complete.

The thermometer sometimes renders valuable aid in differentiating between the above diseases. Capillary bronchitis is normally attended with only moderate febrile movements, the mercury fluctuating between 101° F. and 103° F. A sudden exacerbation of fever in bronchitis, in which the thermometer registers 104° F. or higher, strongly suggests the onset of catarrhal pneumonia; on the other hand, a sudden fall of the mercury, without corresponding improvement in the symptoms, points strongly to collapse.

Prognosis.—In congenital atelectasis, if restorative measures are adopted early and the lesion is not extensive, the prognosis is good. But if the child be premature or feeble, or the fœtal circulatory openings are unclosed, the outlook is bad in the extreme. The prognosis in acquired atelectasis is always grave; occurring in whooping-cough, it is apt to be fatal. Lobular collapse is the initial lesion in many cases of catarrhal pneumonia, of which caseous degeneration and phthisis are not infrequent sequels. Emphysema, more or less extensive, is nearly always left behind, if any considerable tract of lung has been involved in the collapse.

Treatment.—The treatment consists in the adoption of measures and remedies to strengthen the respiratory process, to clear the air-passages of all obstructions, and to sustain the strength. Artificial respiration by any of the recognized methods is of the utmost importance in congenital cases. In crying and coughing, deep, full inspirations are instinctively taken, and hence should be frequently provoked. Infants should not be permitted to sleep too long at one time, or to remain any great

length of time in the same position. Remedies addressed to the bronchial catarrh or other associated disease are indicated. Those remedies should be chosen which, like the preparations of ammonium, increase the flow of serum and lessen the viscidity of the tough secretion which occludes the bronchioles. Opiates should be sparingly used. If not contra-indicated by debility, emetics serve the twofold purpose of expelling viscid phlegm from the bronchial tubes and producing powerful inspirations. Those emetics only are admissible which act promptly and with little depression, as sulphate of copper and ipecac. Alcoholic stimulants are always indicated. Hot immersion baths, made more stimulating by the addition of mustard, and mildly irritating embrocations to the chest are useful. Nutritious diet and tonics, by which the respiratory muscles gain permanent volume and vigor, constitute our chief reliance, as soon as the immediate danger is tided over. *W. J. Conklin.*

ATHAMANTA CRETENSIS, Linn.; Order, *Umbelliferæ.* The fruit of this plant is in the French Pharmacopœia under the name *Daucus de Crète.* The plant is a native of the Alps and other parts of Southern Europe. The fruit is oblong, not flattened, densely hirsute, with slightly prominent ribs, and single *vittæ* in the furrows. There are also often *vittæ* under the ribs.

The substance *Athamantin* comes from *Peucedanum Oreoselinum*, and not from this plant, as the name would lead one to suppose.

Allied Plants and Drugs.—See Anise.

W. P. Bolles.

ATHEROMA. The atheroma is a retention cyst which is developed from the invaginations of epithelium which form the hair-follicle and sebaceous glands. The hair-follicle is primarily the seat of the cyst, but since the sebaceous glands empty into this they also become secondarily involved. The impediment to the escape of the secretions may, however, be below the opening of the glands, and in this case we may have a cyst of the follicle without any participation of the gland. The differences in the character of the contents depend in great part on the extent to which one or the other, the follicle or the sebaceous glands, is involved. If an impediment to the escape of the secretions exists, a tumor must arise from the accumulation of secretion behind the impediment.

But little is known as to the cause of the atheromata. In general these cysts are so innocent and excite so little attention, that they have never been studied very closely. In quite a number of cases trauma has been alleged to be the exciting cause, but there is little foundation for this belief—much less, indeed, than there is for the traumatic theory for the origin of tumors. It is, however, conceivable that a hæmorhage into a hair-follicle might lead to an occlusion of this. The formation of these tumors seems to be more often connected with diseases which lead to the loss of the hair and hinder the throwing off of the epidermis. Erysipelas of the head seems certainly to favor the production of atheromas. They often appear in women just after childbirth, which can possibly be explained from the falling out of the hair, which so often takes place at this time. Anything which produces a loss of the hair of course favors their origin, for they are much more likely to occur in an empty hair-follicle, where the chances of closure of the duct are so much better than in one in which the secretions are conducted out along the hair They have been seen to develop in scars, this being rather due to the distortion of the follicle by the surrounding tissue than to any inflammatory or irritative action. Lücke calls special attention to the fact that they are very much more common in persons with thin than in those with abundant hair.

Atheromas seldom appear before the age of twenty, and are most common between thirty and forty. Men seem rather more disposed to them than women, though on this point we have no reliable statistics. A tendency to them would often seem to be inherited. This is due to an inherited tendency to baldness and other conditions of the hair which favor their occurrence.

The scalp is the most favorite seat of the atheroma, and next to this, perhaps, comes the scrotum; still atheromatous cysts may appear on all parts of the body. On the trunk they are more common on the back and shoulders than on the anterior surface. They are most abundant where the hair-follicles and sebaceous glands are most plentiful. They may assume slightly different shapes in different parts of the body; a fact due, as Virchow says, to the difference in the shape of the hair-follicles. This is most perceptible in the very small examples. When the skin is thin, and the follicle short, small, hard masses, which feel like shot, are produced; these are called milia. When the follicle is longer, a long mass, called comedo, is the result of its occlusion. These very small retention cysts of the hair-follicles are ordinarily not classed with the atheromata. Their structure and mode of origin is the same. Usually the atheromas appear singly, but they are very often multiple; in some cases from twenty to forty may be counted on the head.

The structure of the atheroma is simple, and repeats that of the hair-follicle and sebaceous gland. It consists of a connective-tissue sack lined with epithelium, and filled with the more or less altered secretion of this epithelial lining. The younger and smaller an atheroma is, the thinner is its sack. As the cyst increases in size, the sack becomes thicker in consequence of increase in its epithelial layer. Even in very old cysts the connective-tissue sheath is seldom thick. This tissue carries the vessels which supply the epithelium, and connects the cyst with the surrounding tissues, and most of the pathological changes have their origin in this. The only active growth takes place in the rows of cells which border the connective tissue. These cells are analogous to the Malpighian layer of the skin. As new cells are formed they are pushed from without inward, becoming flatter as they recede from the outermost layer. The active, growing cells which border on the connective tissue are often almost columnar in shape.

The atheroma is round when it first appears, and while it remains small; later, when it enlarges and distends the skin, it assumes on the head a plano-convex shape, owing to the resistance which the skull makes to its growth. Very often a pitting is found in the middle, corresponding to the occluded duct.

In the younger atheromas the duct which has become occluded can always be found; in these cases it can be opened with a fine probe, and the contents squeezed out. In the older ones it is more difficult to find it, and very often it becomes changed into a firm, fibrous cord. This is in consequence of adhesions of its sides after the epithelium has been destroyed.

It is seldom that an atheroma shows more than one cavity; still, some are multilocular. When this is the case it results from disappearance of the partition-wall which separated two distinct cysts. When the formation involves quite a number of hair-follicles, either multilocular cysts can arise, or, by the complete disappearance of all dividing walls, a large simple cyst may be the result.

The contents of the atheroma cyst are formed from the accumulated secretions of the hair-follicles and sebaceous glands. Ordinarily it is a thick, whitish, greasy mass, of about the consistency of soft cheese. The consistency may vary very much; sometimes it will be found quite hard and dry; at other times it becomes changed into a comparatively thin fluid. These differences depend on whether the mass is made up principally of the cast-off epithelial cells of the hair-follicle, or of the secretions of the glands.

Microscopically we find, so constantly as almost to be characteristic of this cyst, the large, flat, shining crystals of cholesterin (see Fig. 344). Other fatty crystals appearing as star-shaped, or in single fine needles, are also often seen. Large flattened epithelial cells often acquire a pearly lustre, and may be mistaken for the tablets of cholesterin. We find epithelial cells, some large and flattened, without a sign of a nucleus. These have come from the inside of the cyst, and represent the horny layer of the skin. From these we can find every transition to the soft granular cells on the outer layer, which are the

same as those in the Malpighian layer of the skin. White blood-corpuscles are occasionally found which are unchanged, and as slight hæmorrhages into the cyst are not very uncommon, we also may find a few red ones. Sometimes small cells similar to the granulation cells are found. There are often seen large masses composed of an infinite number of small fat globules, the so-called *Körnchenkugeln*. These are similar to the large cells found in cerebral softening, and have the same origin. They are white blood-corpuscles which have taken up small fat drops. The epidermis cells may become rolled up into the onion-like pearly bodies which we find in epithelial carcinoma, and as these are often held to be pathognomonic of epithelial carcinoma, they have led to the diagnosis of carcinomatous degeneration. We know that these pearls can be formed under many other conditions than that which prevails in carcinoma. I have noticed once or twice in cysts of this nature coming from the negro, that the contents were darker than ordinary; in one instance the cyst was filled with a mass that was almost black. On microscopic examination, some pigment was found in the epithelial cells, but most of it was scattered through the mass in the shape of small granules. There is no doubt but that most of the pigment was formed in the outside epithelial cells; some might have resulted from a hæmorrhage into the cyst.

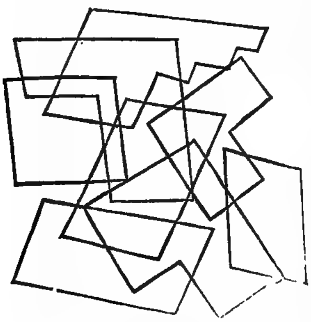


FIG. 344.—Cholesterin Crystals, from an Atheroma.

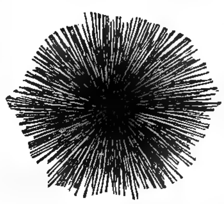


FIG. 345.—Star-shaped Crystal of Margaric Acid, from an Atheroma.

Small thin lanugo hairs are often found. Virchow explains their presence by the fact that several hairs are often found in one follicle. In those cases in which a large amount of hair is found the cyst most probably is a true dermoid cyst which has been mistaken for an atheroma.

Chemical analyses have been made of the contents, but they have shown nothing of importance. Fat is the chief ingredient, and nearly all of the fatty acids and compounds have been found. Leucin and tyrosin, resulting from the breaking down of proteids, are always found in the larger cysts. Lime-salts are generally present, and the entire contents may undergo calcification, and be changed into a hard solid mass. The wall of the cyst in these cases also becomes calcified, and all growth is stopped. The contents may become changed into a hard waxy mass of the consistency of paraffine; this is combined with calcification of the sac. This transformation is a rare one.

FIG. 346.—Other Objects Observed in the Contents of an Atheroma. B, needle-shaped crystals of fatty acid; D, granular cells; E, growing epithelium from the inner lining of cyst wall; F, old epithelial cells seen in profile and flat; G, red blood-corpuscles; H, white blood-corpuscles.

Ossification of the cyst-wall has been seen. Lücke described a case in which the wall was changed into a hard, compact, bony shell, which contained within it masses of calcified epidermis. This is a very rare process, and it is difficult to see how bone could be formed in this locality.

In the atheroma all growth takes place from the epithelium which lines the cyst; consequently the cells nearest the centre are always the oldest. The atheroma may reach the size of an apple, and Sir Astley Cooper has described one which was as large as a cocoanut.

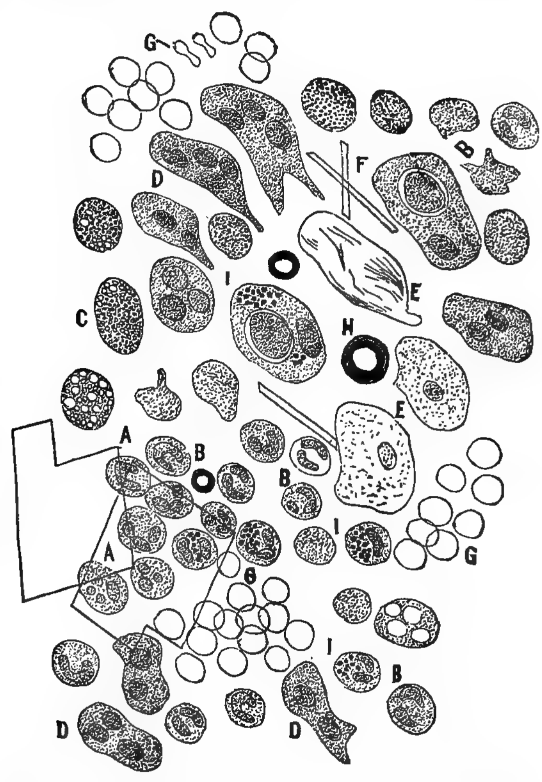


FIG. 347.—Contents of a suppurating Atheroma Cyst. A, cholesterin crystals; B, pus-corpuscles; C, granule cells; D, growing epithelium; E, old epithelium; F, needle-shaped crystals of fatty acid; G, red blood-corpuscles; H, fat drops; I, cells containing micrococci.

Ordinarily the skin over an atheroma is unchanged; the hair always seems to be thinner, but this is due to a distention of the skin, and the same number of hairs are made to cover more ground. For the same reason the follicular openings will appear to be larger over the cyst than elsewhere. Adherence of the cyst to the skin is usually caused by inflammation due to traumas. The small vessels passing over the surface of the cyst are very often dilated and tortuous. The parts beneath the atheroma always have a passive relation to it. The cyst may become adherent to the periosteum, but the pressure which it exerts on the bone never makes any impression upon it.

Inflammation may make very decided alterations in the cyst. Most often this inflammation is the result of trauma; the combing of the head over the tumor is a very frequent exciting cause of the inflammation. Inflammation may lead simply to a thickening of the cyst-wall and adhesion to the surrounding tissues, or it may cause the

cyst to burst. When this is the case the contents escape through the opening, and, in consequence of the decomposition set up by the entry of lower organisms, the cyst empties an extremely fetid, disagreeable pus. When the opening is small, very frequently the suppuration does not involve the whole sac, and a fistulous opening is established from which the freshly secreted epithelium, fat, etc., constantly escape. This inflammation may destroy the entire epithelial lining of the sac, and leave a simple abscess cavity, which will heal by granulation just as happens in the case of any other abscess. The process is most unfavorable when only portions of the epithelium are destroyed; the portions remaining will then always prevent the cavity from closing. From the granulating surface large fungous granulations grow out, and a very foul pus, mixed with epithelium, is constantly secreted. The whole covering of the cyst is lost by ulceration, and a surface covered with these fungous granulations is exposed. The residue of the epithelium acts as a foreign body, and prevents the cyst from closing as a simple abscess cavity would. Such fungous granulating surfaces have often been mistaken for carcinomas, which indeed they very much resemble macroscopically. Epithelial carcinomas seem often to originate in such atheromas, and should a disposition to carcinoma be present the cyst would be a favorable exciting cause. This carcinoma formation in the cyst is only seen in old people. Sarcoma can also develop in the granulations, and when this is combined with the active epithelial proliferation in the remains of the cyst-wall, a very complex structure may result. It is doubtful whether true carcinomas marked by unlimited growth, invasion of surrounding tissues, and formation of metastases do result. We may have, and very often do have, structures which histologically have all the characters of carcinoma, the atypical cell-growth, formation of pearls, etc.; but the growth of the epithelium is more a surface one, and does not extend deeper than the inflamed tissue beneath. Such a growth can hardly be called carcinomatous, because the element of malignity is wanting.

The *diagnosis* of atheroma cysts is not difficult. They should only be confounded with, possibly, hygromas or dermoid cysts. From these they can be distinguished by the time and manner of origin, by the greater thickness of their walls, and by the firmness of their contents. It is often a matter of difficulty to diagnose between an ulcerated cyst and a carcinoma; here the history and slight tendency to extension will aid us in our diagnosis. *W. T. Councilman.*

ATHETOSIS (ἄθετος, without fixed position). A cerebral affection characterized mainly by continuous, slow, deliberate motion of the fingers and toes, and by inability to retain them in any position in which they may be placed.

Although the name for this rare affection was first proposed in 1871, by Dr. William A. Hammond, of New York, whose systematic description of the complaint entitles it to a place on the nosological list as a distinct pathological entity, it appears that former observers have reported cases in which the symptoms resemble those of athetosis; but their mention being a matter of no importance, it suffices to refer to that only of Dr. J. C. Hubbard, of Ashtabula, O., who, under date of January 11, 1870, gives an excellent report of a case in which athetoid symptoms form a prominent feature. The report, with two accompanying photographs, is mentioned by Hammond, in the late edition of his "Treatise on Nervous Diseases," as an illustrative history of a case in which the symptoms of athetosis are clearly indicated.

This new differentiation by the American physician being now recognized by eminent pathologists both in English-speaking and Continental countries, numerous cases of athetosis are reported, many of which, however, are not strictly in accord with Hammond's definition; but the details in regard to the affection are well described, notwithstanding the objections of those who saw in athetosis nothing more than a complex symptom, or a variety of post-hemiplegic chorea.

The morbid movements of the fingers and toes, symptomatic of athetosis, are involuntary, grotesque, and complex in character, being of a more complicated form than those of simple flexion and extension. The contractions, which do not cease even during sleep, come on slowly with apparent deliberation and with great force. The fingers and toes assume various distorted positions, and carry out movements that would be nearly impossible in the normal state. There is a peculiar distorted position of the thumb and of the index-finger, with sprawling abduction of the other fingers, which the hand constantly tends to assume in typical cases, and when once seen can never be mistaken. That which appears to be pathognomonic of athetosis is the localization and the peculiarity of the incessant complex involuntary movements. They seem to prefer the peripheric ends of the extremities, such as the fingers and toes, and rarely the face. A gliding protrusion of the head is occasionally a characteristic of the disease. The patient is able to control these movements for a limited time by position and the exercise of an extreme effort of the will.

The essential feature of the disease seems to be an inco-ordination between the flexors and extensors of the muscles of the fingers and toes, in consequence of a lesion in the centre controlling the muscular movements of these members. It has been noted that the phenomena have partly the character of associated movements, for while the fingers moved, the arm was hard and rigid, and during the motion of the toes the muscles of the calf were in a state of tonic contraction. The muscles of the affected extremity are hypertrophied; but it often happens that the hand and foot affected may be atrophied. There is also vaso-motor disturbance in the affected extremity, which may be red, livid, moist, and colder than the corresponding extremity, and pain may also occur in the affected limbs. In some cases, the electric contractility of the muscles is enfeebled or it is increased; in others, it is normal. Relaxation of the ligaments and joints of the affected extremities has also been noted as a characteristic. The ankle clonus is frequently present.

The advent of athetosis is always sudden, and in most cases occurs in patients whose hereditary antecedents are bad, or in those who have suffered from an attack of convulsion and unconsciousness, or what is more common, hemiplegia, a distinct attack of which in many cases precedes the appearance of the clonic spasm. Hammond says, however, that of the eight cases occurring in his experience, hemiplegia was not an antecedent condition in four. Athetosis is also observed in epileptics, in drunkards, and in psychical disturbances. Adults of irregular habits, between thirty and thirty-five years, appear to be the subjects of the affection. Two cases are, however, reported to have occurred in consequence of sudden fright in girls of seven, both of whom had histories of hemicrania confined to the left side, and in another case, the mother was exposed in pregnancy to violent psychical excitement. A case is reported to have followed infantile encephalitis. It is not known that sex is an etiological factor, nor does the affection appear to be confined more to one side than another. In thirty-five cases it was confined to the right side in nineteen, and to the left in sixteen. When athetosis is confined to one side of the body it is designated as *unilateral* or *hemiathetosis*, and is symptomatic of disease of the cerebral centre.

Double or *bilateral* athetosis, which is generally idiopathic and unaccompanied by hemiplegia, occurs in cases in which there is probable atrophy of the brain. In fact, there seems to be a close relation between cerebral atrophy and this affection, the reason for which is not clear. A case is reported in which the spasms occurred in the right hand and the left foot. The muscles of the face and neck appear to be affected to a greater extent in this form than in the unilateral; there are no sensory disturbances; it may or may not be associated with idiocy, and is not necessarily post-hemiplegic.

Athetosis being a combination of symptoms somewhat resembling paralysis agitans, care should be taken not to confound it with that affection. A likeness to athetosis

is also found in senile trembling; in the tremor characteristic of mercurial poisoning, and in that of disseminated sclerosis of the nerve-centres. Other analogous conditions are the spastic contractions common after hemiplegia in children, and the movements that take place in chorea. Athetosis may be distinguished from all these by the peculiarity of the movements, which are slow, systematic, uniform, and apparently determinate. They have not the quick, jerky, unexpected movements of other forms of clonic spasm, but a slower, gliding, methodical, quasi-rhythmical motion that may be compared to the peristaltic action of some involuntary muscles, or to the movements in muscles affected by a peculiar form of cramp. The anomalous position of the hand, which is an exaggeration of that assumed by a base-ball catcher, is an excellent diagnostic sign; slowness of speech and impairment of the intellect are also diagnostic aids.

The data furnished thus far by the clinical histories of the observed cases seem to warrant the act of making a distinct pathological entity of athetosis and the placing of it in the category of brain diseases. The pathological characteristics of athetosis appear to be degenerative changes in the corpus striatum and the optic thalamus. In one recorded case the disease was thought to be caused by an embolon blocking the middle cerebral artery; and the post-mortem examination showed the disease to be limited to the optic thalamus, the corpus striatum, and the parts just external, thus justifying Dr. Hammond's original surmise as to the probable seat of the affection, before he had as yet had an opportunity to ascertain by necropsy the nature of the lesion that causes the symptoms. The true nature of this class of cases, however, awaits further pathological evidence. Later observers think that the clinical manifestations of athetosis are owing to functional disturbances or obliquity in the motor centres rather than to any recognizable structural change.

So far no case of athetosis has recovered, although slight cases may do so approximately. The means used to bring about a cure consist in the administration of sedatives and nerve-tonics and the application of galvanism. The chloride of barium, arsenic, ergot, and cannabis Indica have all been given with indifferent results. On one hand, it is reported that marked improvement in two cases followed the application of the constant current; on the other, that both galvanization and faradization led to no results. It would probably be well for the patient to exercise the fingers by a graduated system of lifting in conjunction with vigorous efforts of the will.

Irving C. Rosse.

ATLANTIC CITY. (Detailed explanation of the accompanying chart, and suggestions as to the best method of using it, will be found in the article on Climate.) For many years past a well-known seaside resort during the summer months, this place has more recently come into notice as also possessing special climatic advantages, during the winter and spring seasons, which are of such a nature as to recommend it for the residence of invalids desiring to escape the greater rigors and inclemency of climate characteristic of the northern section of the United States, and particularly of the larger cities lying on or near the sea-coast.

Atlantic City lies upon the southeastern coast of the State of New Jersey (Lat. 39° 22′ N., Long. 74° 25′ W.), at a point distant from New York City about ninety-five miles, in a south-southwest direction, and about fifty-five miles southeast of Philadelphia. The city, which has a population of about eight thousand souls (increased to forty thousand during the summer season), is built upon a sandy island, separated from the mainland by a strip of salt-water marsh-land, intersected by bays and lagoons, which strip skirts the whole coast of New Jersey for a distance of some ninety-five or one hundred miles, from the mouth of the Manasquan River, fifty-five miles north of Atlantic City, to the extremity of Cape May peninsula, forty miles southwest of the latter. This strip has its greatest width in the neighborhood of Atlantic City, and just opposite the latter point it is some six or seven miles broad.

The coast-line of New Jersey, which runs in a direction almost due north and south from Sandy Hook (Lat. 40° 28′) to Barnegat (Lat. 39° 48′), trends from the last-mentioned point to its extremity at Cape May (Lat. 38° 56′) in a southwesterly direction, and this southwesterly trend becomes especially marked at that part of the coast where Atlantic City is located. From this configuration of the coast-line it results that Atlantic City enjoys a more nearly southerly exposure than does any other point upon the ocean shore of the State, with the single exception of Cape May. "One of the overflow currents of the Gulf Stream approaches within sixty-five miles of Atlantic City, while it is one hundred and fifty miles distant from Sandy Hook. The principal current is farther away, being one hundred and thirty-five miles from Atlantic City, and one hundred and eighty-five miles from Sandy Hook, and about the same distance from Long Branch and Montauk Point." "But the exceptional mildness of this climate may be attributed to the peculiar course of the Gulf Stream in this vicinity as much as to its proximity. The innermost current, according to the map received from the Coast Survey office, has a direction opposite Atlantic City of east-northeast, but turns more and more to the eastward till in latitude 40°—that of Philadelphia—it bears nearly due east. The main current turns more abruptly, and a little north of latitude 38°, some distance to the southward of Atlantic City, has a course directly eastward. Our south, southeast, and east winds, then, must all pass for three hundred to five hundred miles at least over more or less heated water which has come directly from the Gulf of Mexico. Our only ocean breezes not affected in this way are those from the northeast. But for places farther up the coast, particularly those north of latitude 40°, the case is different. Neither their northeast nor east winds can be appreciably modified by the Gulf Stream. Their south and southeast winds may be favorably influenced to some extent, but less than are the same winds at Atlantic City, since they pass over a much larger surface of cold water after crossing the Gulf Stream" (Dr. Boardman Reed in "Atlantic City as a Winter Health Resort").

An examination of the geological map of the State of New Jersey, accompanying the "Annual Report of the State Geologist for the Year 1881," shows that a considerable portion of the southern half of the State is occupied by "pine-land" soils. The greater extent of the regions so occupied is to be found to the north and northwest of Atlantic City, although less extensive regions possessing similar soil and vegetation lie to the west and to the southwest of the latter point. None of these "pine-land" districts are in close proximity to Atlantic City; yet it is probable that they exert a modifying effect upon the climate of this place, as tending slightly to increase the temperature and the dryness of winds blowing from the north and west. All land-winds, before reaching Atlantic City, must pass over the wide strip of salt-marsh intervening between the mainland and the island upon which the town is built, as well as over the sandy soil to be found both upon the sea-margin of the mainland and upon the island itself, and constituting, in fact, the only variety of soil of which the latter is composed.

All winds reaching Atlantic City from points between south and west must pass either over the waters of the Atlantic itself (in the case of south to southwest winds), or else over those of Delaware Bay, twenty to twenty-five miles broad, and over the threefold strip of salt-water marsh-land lining both shores of the Bay as well as the Atlantic coast of New Jersey.

In a west-southwest direction the distance from Atlantic City to the shore of Delaware Bay is only twenty-nine miles "as the crow flies."

Of shelter against winds blowing from the north, or from any other point of the compass, Atlantic City has none; but, unfortunately for their reputation as desirable health resorts during the winter months, the same remark applies with equal force to all other stations on the Atlantic coast of the United States.

We have not, at least not upon this side of our continent, any counterpart of the English South Coast, or of the still more famous Genoese Riviera; the general trend of our shore-line, and the absence of any high range of hills lying close to the sea, precluding the existence of any such harbors of refuge against the assaults of "old Boreas."

In the absence of shelter from the winds, it is consoling to reflect that their force and frequency at Atlantic City are less, in all probability, than at any other well-known place of resort lying upon the New Jersey coast. In a table showing the average yearly movement of the atmosphere for the five years, 1880 to 1884, inclusive, the following figures stand opposite the four stations, Atlantic City, Barnegat, Cape May, and Sandy Hook:—Atlantic City, 82.630; Barnegat, 122.988; Cape May, 130.055; Sandy Hook, 118.450. The figures of this table (quoted from "Atlantic City as a Winter Resort," by B. A. Blundon, Sergeant, Signal Service, U. S. A.), reveal the fact that, during the five years above mentioned, the average amount of wind blowing at Atlantic City was 31 per cent. less than at Sandy Hook, 33 per cent. less than at Barnegat, and 37 per cent. less than at Cape May. Concerning the relative frequency of winds blowing from the different points of the compass at Atlantic City, a table giving the result of observations made during the three years intervening between July, 1876, and July 1879, shows that 9 per cent. of such winds were from the north, 11.7 per cent. were from the northeast, 15.3 per cent. were from the northwest, 16.1 per cent. were from the west, 8.3 per cent. were from the east, 6.3 per cent were from the southeast, 15.9 per cent. were from the southwest, and 17.4 per cent. were from the south. (The table from which these figures are quoted is to be found on page 51 of the Report of the New Jersey State Geologist above referred to, being contained in the very interesting discussion written by Professor J. C. Smock, the Assistant State Geologist, on the climate of New Jersey, and constituting the Appendix of said Report.)

For a knowledge of the prevailing direction of the wind at Atlantic City during each of the twelve months of the year, during each of the four seasons, and during the year taken as a whole, the reader may be referred to the chart which accompanies the present article, and which the writer obtained from the Chief Signal Office at Washington, through the kindness of Professor Smock.

During the warmer part of the year Atlantic City, and all other places lying upon the New Jersey coast, are visited daily (with but rare exceptions) by a delightful sea-breeze, which begins to blow at about eleven or twelve o'clock in the day, and lasts until nightfall. A more particular account of these sea-breezes, of their causation, and of the distance inland from the coast to which their influence extends, may be found in Professor Smock's Appendix already referred to above.

A particularly striking feature in the climate of Atlantic City is the comparatively small amount of the annual rainfall. A table on page 11 of the pamphlet entitled, "Atlantic City as a Winter Resort," shows that the rainfall is less in amount at Atlantic City than at any other point on the Atlantic coast of the United States, with the single exception of Portland, Me.; and that it is fully twenty per cent. less than at the neighboring station of Barnegat—a singular fact, and one very difficult of explanation.

The figure for the relative humidity of Atlantic City (79.4 per cent.) would seem to show that the climate of the place is not a particularly dry one; and, indeed, this is no more than we should reasonably expect in a place

Climate of Atlantic City, N. J.—Latitude 39° 22′, *Longitude* 74° 25′.—*Period of Observations, January* 1, 1874, *to December*, 1883.—*Elevation of Barom. Cistern above the Sea-level*, 13 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at hours of			Average mean temperature deduced from column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below 32°.	Greatest number of days in any single month on which the temperature was above 90°.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	29.5	35.5	31.4	32.1	41.1	27.2	39.5	25.6	64.0	44.0	13.0	-3	29	0
February...	31.0	37.4	32.8	33.7	37.9	26.3	42.4	27.6	71.0	46.0	20.3	-5	25	0
March......	36.0	42.3	37.1	38.4	43.6	35.0	45.5	31.4	72.0	52.0	22.0	10	20	0
April.......	44.7	49.7	44.3	46.2	52.3	42.4	53.5	39.8	79.0	63.0	34.0	19	9	0
May........	56.2	60.6	54.8	57.2	63.2	53.2	63.9	51.2	89.0	74.5	44.5	33	0	0
June.......	66.2	70.4	64.0	66.8	69.5	64.7	74.5	60.5	93.0	84.0	53.0	45	0	2
July.......	71.5	76.3	69.6	72.4	73.5	70.4	79.9	66 3	99.0	82.0	61.0	58	0	3
August.....	70.6	75.4	70.0	72.0	74.8	69.7	77.4	65.2	91.8	83.0	62.5	53	0	1
September..	65.2	70.7	65.3	67.0	72.6	64.0	74.8	62:2	94.0	80.0	55.0	43	0	1
October....	54.7	60.9	55.4	57.0	61.2	50.8	64.3	51.4	83.0	73.8	39.8	29	2	0
November..	41.8	47.8	43.0	44.2	48.8	40.5	51.3	37.0	72.0	55.0	25.0	10	13	0
December..	33.3	38.4	34.8	35.5	42.2	26.9	41.9	28.2	64.0	47.0	19.0	-7	30	0
Spring......	......	......	......	47.2	51.5	44.2	......	......	......	......	......	......	......	......
Summer....	......	......	......	70.4	72.0	69.5	......	......	......	......	......	......	......	......
Autumn....	......	......	......	56.0	60.9	52.8	......	......	......	......	......	......	......	......
Winter.....	......	......	......	33.4	40.1	28.9	......	......	......	......	......	......	......	......
Year........	......	......	......	51.9	58.3	49.2	......	......	......	......	......	......	......	......

	J	K	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of clear and fair days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
	Degrees.			Inches.	From	Miles.
January....	67.0	80.7	18.6	3.66	N.W.	9.7
February...	76.0	77.6	18.8	3.06	N.W.	10.8
March......	62.0	77.0	21.0	3.96	N.W.	12.0
April.......	60.0	76.4	19.3	3.59	N.W.	11.7
May........	56.0	79.1	23.4	2.35	S.	10.1
June........	48.0	81.7	23.4	2.32	S.	8.7
July........	46.0	82.1	24.3	2.99	S.	7.7
August.....	38.8	82.2	21.4	5.23	S.	9.0
September..	51.0	81.3	21.1	3.82	S.	10.4
October.....	54.0	78.3	22.8	2.80	W.	9.6
November..	62.0	76.9	20.0	3.38	W.	9.7
December..	71.0	79.5	20.9	4.02	N.W.	9.7
Spring......	79.0	77.5	63.7	9.90	N.W.	11.3
Summer....	54.0	82.0	69.1	10.54	S.	8.5
Autumn....	84.0	78.8	63.9	10.00	W.	9.9
Winter......	78.0	79.9	58.3	10.74	N.W.	10.1
Year........	10.6	79.4	255.0	41.18	N.W.	9.9

lying directly upon the shore of the ocean, and, withal, separated from the mainland by some six or seven miles of intervening marsh-land and by salt-water lagoons. Nevertheless, the dryness of the climate is especially noticed by all the visitors to Atlantic City, whose accounts of the place have hitherto come to the notice of the writer; even a correspondent of the latter, who "damned" the place with his extremely "faint praise," having gone so far as to admit that its climate was a "comparatively dry one." It is claimed that the relative humidity figures from the Signal Service Observatory at this station are misleading as an indication of the dryness of the Atlantic City atmosphere, on account of the great proximity of the station to the beach, the instruments of observation being, for this reason, "affected by the spray during strong winds off the water, and by occasional morning mists which do not extend back into the town" ("Atlantic City as a Winter Health Resort," quoted by Signal Service Sergeant Blundon in "Atlantic City as a Winter Resort"). This explanation is certainly a plausible one; and, that the climate of Atlantic City is, at least, a *comparatively* dry one, there appears to be abundant testimony to prove.

The so-called "cold waves," so well known (indeed, perhaps, too well known) to all residents in that portion of the United States which lies to the eastward of the Rocky Mountain chain, are said to be much less severely felt at Atlantic City than they are at points lying in the same latitude, but removed from the coast.

Owing also to the immediate proximity of the ocean and to the sandy nature of its soil, snow seldom lies upon the ground at Atlantic City for any length of time, and sleighing is quite unknown throughout the entire course of some winters.

Such frequent reference has already been made to the abundance of marsh-land in the immediate vicinity of the town, that it is only proper to call attention to the fact, that these marshes are of the purely salt-water variety; and that Atlantic City is many miles distant from any large body of fresh-water, such streams as empty into the ocean along this part of the New Jersey coast being, without exception, of insignificant size, and therefore inadequate to the production of the combined fresh- and salt-water marshes, which are believed to be such a prolific source of malarial poisoning at many other points along our Atlantic coast.

"So far, therefore, as concerns malaria . . . Atlantic City seems to be highly favored. Intermittent and remittent are strangers to the regular residents, and it is the constant experience of malarial patients coming here, that they obtain rapid relief with far less medication than at home; often, especially in the case of children, with no medication at all." ("The Sanitary Condition of our Seashore Health Resorts," by Dr. Boardman Reed, *Medical and Surgical Reporter*, July 9, 1881). The vital statistics accompanying the Report of the Board of Health of the State of New Jersey, for the year 1884, show that during the course of that year, no deaths attributed to malarial disease were reported to the authorities as having occurred in Atlantic County, or in the adjoining county of Cape May.

Concerning the all-important matters of drainage and water-supply at Atlantic City, it would appear that, until quite recently, no provision had been made which could reasonably be considered at all adequate to supplying the wants of so large and so rapidly growing a town. No longer ago than last March (March, 1885), the writer received a letter from a gentleman who was passing the winter at Atlantic City, in which there occurred the following statement: "The water-supply is very bad indeed, and much of the city water passes through lead pipes. There have been many cases of lead-poisoning." "Houses huddled together," and "stinking privy-vaults," are also alluded to in another letter received from this same correspondent on the 14th of the preceding month (Febuary, 1885). A report from the secretary of the town health board, which will be found on pages 136–138 of the Eighth Annual Report of the State Board of Health, already referred to, contains a caution against the use of lead pipes, but describes the quality of the water as excellent. This same report (1884), speaks of a proposed system of underground drainage for Atlantic City, and alludes to the system of sewage removal already in vogue, in a manner far less condemnatory than did the writer's private correspondent of last winter. From both the writer would be led to infer that very much depended upon the quarter of the town selected for residence at Atlantic City, as well as upon the sanitary arrangements of the particular hotel or boarding-house chosen as such place of residence. It was evident, from the tone and tenor of his letter, that the private correspondent above referred to had been by no means fortunate in this latter respect.

The following letter, received shortly before going to press, speaks for itself, and shows that the objectionable features in the important sanitary factors of drainage and water-supply at Atlantic City are now receiving, at the hands of the residents and town authorities, the degree of attention which they deserve, and that the errors and oversights of the past are in a fair way to be immediately and adequately rectified.

ATLANTIC CITY, N. J., June 4, 1885.

DR. HUNTINGTON RICHARDS, New York City:

DEAR DOCTOR—Yours of yesterday at hand. Your questions as to the water-supply of Atlantic City are fully answered by the report of the water company, a copy of which is sent to you by this mail. You will learn from that report that the character of the water is excellent; the supply as now enlarged amply sufficient for the present, and all probable future wants of the city. The precise sources of supply are Absecon Creek and a small stream tributary thereto. These arise and flow through a partly barren and sparsely settled country. There are no manufactories along their banks, with the exception of one or two saw-mills, and possibly a grist-mill.

The drainage of Atlantic City has, in recent years, undoubtedly been insufficient. It has just been supplanted by a radically new system of underground sewerage. This is known as the "West System," and comprises a pumping station, with terra-cotta pipes of the best make, laid far below the water-level, the sewage flowing through these to the bottom of a walled well by gravity, and thence pumped several miles from the town to filtering sheds, where the solid part is separated and prepared for sale as a fertilizer. The pipes are already laid in all those portions of the town occupied by the hotels. The well or reservoir is about completed, and before the first of July next I verily believe that we shall have in operation the best sewerage system to be found on the Atlantic coast. Having labored hard, as President of our Board of Health, to have introduced here such an improved system, I naturally feel a pride in the result.

If you need any further data concerning the place, please notify me and I will reply at once.

Yours very truly,
BOARDMAN REED.

Concerning the class of invalids likely to derive benefit from a stay at Atlantic City during the winter months, it may be remarked that many favorable results in the treatment of diseases of the respiratory system, including cases of pulmonary phthisis, when not too far advanced, have been reported by physicians as attributable to a sojourn at this comparatively dry and comparatively mild and equable northern seaside resort. The chief recommendation of Atlantic City, in the writer's own opinion, is its great accessibility to the large cities of New York and Philadelphia, rendering it quite an easy matter for invalids, convalescents, and persons particularly prone to suffer from the effects of cold and dampness, to resort thither during the whole or a part of the winter and early spring seasons, and, by so doing, to escape in great measure the very trying weather so characteristic of our seaboard cities during the colder portion of the year. Of the advantages of Atlantic City as a summer seaside resort it is unnecessary here to speak.

Hotels and boarding-houses are abundantly numerous

at Atlantic City, their actual number being said to exceed four hundred. Many of them are very good indeed. Some, of course, are equally poor and undesirable.

Huntington Richards.

ATROPHY. The term atrophy expresses a condition in which there is a diminution in the size or number of tissue-elements, without any accompanying change of structure or chemical constitution. Atrophy excludes, therefore, the idea of degeneration. Nevertheless it is commonly attended by loss of weight, lessening of volume, and impairment of function. Atrophic organs, as a rule, contain less blood than normal ones. Often they are also firmer, drier, and less elastic than in health. Microscopical examination shows that the parenchyma suffers first, and more than the supporting framework of interstitial tissue. Indeed the latter may remain quite intact, or even continue to grow, while the proper cells of an organ have almost completely disappeared. In the liver, the muscles, and the cerebro-spinal system this peculiarity is especially well marked.

A distinction between simple atrophy, in which the histological elements are merely diminished in size, and so-called numerical atrophy, in which their number has been reduced by the complete wasting away of some cells, is without practical significance. Atrophy may be general, involving all the organs and tissues of the body, or it may be partial and limited to particular localities. In consequence of arrested development, entire organs, or parts of organs, may be ill-grown, misformed, or even quite wanting. The whole body, or any of its component parts may also be dwarfed or stunted. Such dwarfing may happen before or after birth. Now defective development of this kind should not be confounded with atrophy proper. For the latter is a retrogressive process occurring in parts that were originally normal and well formed.

As is well known, before puberty we observe a preponderance of cell-growth over cell-decay ; then follows a period of adult equilibrium, until finally with advancing years, decay gains the upper hand. But long before the general atrophy of old age there occurs a so-called physiological atrophy of particular organs. The obliteration of certain fœtal blood-vessels (ductus Botalli, etc.), the disappearance of the Wolffian bodies, the shedding of the milk-teeth, and the complete shrinkage of the thymus gland before the age of fourteen are well known though imperfectly understood instances of physiological atrophy. Thus, too, the female generative organs shrink before old age, and cease to perform their function. Indeed, certain tissues, like hyaline cartilage, may be regarded as essentially temporary structures.

In contradistinction to simple atrophy of a physiological type, we have the truly pathological variety. It may occur in any tissue, organ, or system of the body. Emaciation and marasmus are its most conspicuous signs. Although, as already indicated, atrophy in the strictest sense means merely a diminution in size of different cells and fibres, it is, nevertheless, commonly found to be accompanied by various degrees of degeneration. Granulo-fatty metamorphosis is most frequently noticed in connection with it. Among the causes that lead to atrophy may be mentioned :

1. *Insufficient nutrition.* This may be due to general anæmia, to morbid changes in the vascular system, or to defective assimilation, depending upon a variety of other conditions. Adipose tissue, for example, quickly wastes, if fat or fat-forming substances are not supplied in adequate amount. The bony structures become brittle and friable whenever lime-salts are persistently withheld. Now it is a noteworthy fact that in continued starvation the various tissues are by no means equally affected. Fatty tissue is always first to disappear, and the loss may amount to as much as ninety per cent. of its weight. Muscle-tissue comes next, and may atrophy up to about forty-five per cent. On the other hand, the cerebro-spinal system, and often the heart show little or no loss of substance, even when death has resulted from starvation. A remarkable fact may be mentioned in this connection, namely, the persistence of lipomatous tumors, even in those cases in which adipose tissue generally is wasted to the last degree. An explanation of this peculiar phenomenon has not yet been found.

Under this heading we must also include passive atrophy, so-called. Compression-atrophy is the most prominent illustration of this variety. As the result of mechanical agencies, we find the familiar deformity of the Chinese foot, the artificial flat head of some Indian tribes, the liver atrophy of tight lacing, the indentures produced by wearing rings, garters, and similar constricting appliances. The altered joints witnessed in pes valgus and genu valgum also belong to this category. The alveolar processes of both maxillary bones show passive atrophy in consequence of mastication. In hydronephrosis the renal parenchyma may waste to such an extent that there seems to be left only the capsule of the kidney. The pressure resulting from aneurism often causes muscle and even bone to atrophy. The same also applies to varicose veins.

2. *Inaction.* Atrophy generally results from suspended or reduced functional activity. If through some influence a gland, a muscle, or even a group of cells is condemned to inaction, atrophy soon makes its appearance. Familiar illustrations of atrophy, due to inaction, are found in the wasting of the optic nerve, following destructive lesions of the bulbus oculi, in the wasting of muscles long at rest, and of the mammary gland in advancing years. The metamorphosis of the umbilical vessels, of the ductus arteriosus, of the Wolffian bodies before or soon after birth, of the thymus gland in adolescence, may also be regarded as due to a cessation of functional activity. The involution of the uterus after child-birth is a more complicated process, partly due to atrophy and partly to degenerative changes. It certainly illustrates the most formidable retrogressive metamorphosis that occurs within physiological limits. The muscular coat of the uterus, its mucous membrane, blood-vessels, and lymphatics, are all involved in the change that culminates in restoring the puerperal organ to almost its original size.

3. *Perversion or abolition of nervous influence.* This is trophoneurotic wasting, and the precise *modus operandi* of disturbed or interrupted innervation is by no means clearly understood. It is perhaps best exemplified in the very rapid atrophy of muscles where their proper nerves are affected, or where certain ganglia-cells of the spinal cord are diseased. Muscles robbed of nervous influence atrophy much quicker than those which are condemned to remain at rest. Poliomyelitis anterior, progressive bulbar paralysis, and various peripheral palsies afford familiar illustrations of this variety. The skin becomes much attenuated, and assumes a glossy appearance, especially noticeable in toes and fingers in certain peripheral paralyses. In mania, melancholia, and dementia, but especially in progressive paresis, general atrophy is a well-known symptom. Hemiatrophia circumscripta totalis also belongs to this category.

4. *Excessive waste.* All conditions attended by much loss of nutritive material lead to atrophy. Repeated hæmorrhages, chronic suppuration, the long-continued excretion of albumen or sugar, and similar processes produce well-marked wasting. Indeed whenever tissue-repair is outstripped by tissue-waste atrophy must needs be the result. All febrile conditions give abundant proof of this statement. In fact many heterogeneous affections, all characterized by more or less rapid atrophy, are still grouped together in some text-books under the common designation of wasting diseases.

The course of the various atrophies must naturally be altogether dependent upon their causation. Total atrophy is observed only when the primary histogenetic activity is at fault, as in the wasting of the thymus gland, the disappearance of the pupillary membrane, the obliteration of certain fœtal vessels. In all partial atrophies, depending upon other causes, restoration is possible. Advanced atrophy of vital organs is of course not compatible with life. But organs of minor importance in the economy may shrink and shrivel without much disturbance of the general health.

Edmund C. Wendt.

AUDINAC, in the departement of the Ariège, distant 10 kilos ($6\frac{1}{4}$ miles) from St. Girons. A good resort for invalids suffering from functional disturbance of the alimentary canal and urinary system. The temperature of the water is 21° C. (70° F.). The total solids per 1,000 parts fluctuate between 16 and 19. The chief constituents are sulphates of magnesium and calcium, and nitrates. There are also present some iron and manganese, and CO_2 in insignificant quantity. *H. F.*

AUDITORY CANAL. Anatomy and Physiology.—The external auditory canal extends from the bottom of the concha to the membrana tympani, and consists of an outer portion which is cartilaginous, and an inner portion which is bony. The former, a continuation inward of the concha, is not cartilaginous in its whole extent. The cartilage is wanting in the upper and posterior part of the canal, which space is covered by a membranous layer, continuous with the lining membrane of the canal. The canal at its outer extremity, close to the auricle, is composed mostly of cartilage. The membranous portion, though forming but a small part of the canal at its commencement, gradually replaces the cartilage, so that at its inner extremity almost the entire circumference is membranous. The cartilage at this inner extremity (*c*) appears simply as a narrow, rounded point. Running transversely in the cartilage of the canal are the *fissuræ Santorini.* There are generally two large fissures, filled up by fibrous tissue; their direction and extent are by no means constant. They allow the canal to be straightened during an examination of the membrana tympani, by permitting mobility of the different parts of the cartilaginous canal.

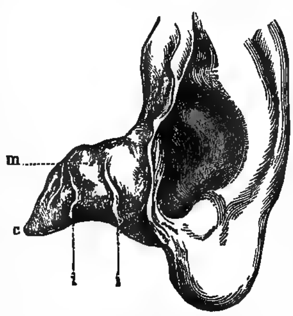


Fig. 348.—*m*, Cartilaginous meatus; *c*, inner extremity of the cartilaginous meatus; *i i*, fissuræ Santorini.

The parotid gland is in relation with the inferior wall of the canal, so that in case of abscess of this gland pus may force itself through one of these fissures. An ulcer in the canal may also produce a suppurative inflammation of this gland. The inner end of the cartilaginous canal is joined to the outer margin of the osseous meatus by flexible elastic connective tissue, a fact of importance because, by traction on the auricle, a change of position of the cartilaginous portion can be produced. Dense connective tissue, containing elastic fibres, joins the inferior and lateral margins of the bony and cartilaginous canals, while above, the fibrous portion of the cartilaginous canal is continuous with the lining membrane of the osseous canal. In the new-born infant in place of the osseous canal there exists only a bony ring, the *annulus tympanicus*, and joined to its outer margin is a membranous canal, which ossifies from within outward during the early years of childhood. The *annulus tympanicus* is not a complete ring. There is an opening in the upper and posterior part of the periphery, which space is called the Rivinian segment. The two free extremities of the ring are attached to the squamous portion of the temporal bone.


Fig. 349.—Annulus Tympanicus.

The temporal bone is developed from four points, not including those for the internal ear and ossicles. There is one for the zygoma and squamous portion; one for the mastoid and petrous portions; one for the *annulus tympanicus*, which gradually forms the anterior, inferior, and superior walls of the bony auditory canal; and one, finally, for the styloid process. In the completely developed temporal bone the superior wall of the osseous meatus is formed by the horizontal portion of the temporal bone lying beneath the line of the zygomatic arch. This horizontal portion together with the mastoid process form a part of the posterior wall. If a perpendicular section be made of the osseous canal in an adult it will be seen that the superior wall forms almost a right angle with the squamous portion of the temporal bone. It consists of two osseous plates, enclosing cellular spaces, which vary in size and number. According to Von Troeltsch there is a partial communication between them and the tympanic cavity and mastoid cells. The dura mater rests upon the superior plate. In rare cases of carious disease of the superior wall of the meatus, inflammation may reach the dura mater and produce fatal meningitis.

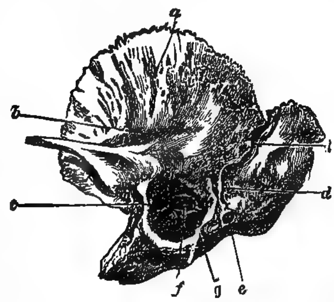


Fig. 350.—Temporal Bone of New-born Infant. *a*, Upper part of squamous portion; *b*, lower part of the same; *c*, annulus tympanicus; *d*, fissura petro-squamosa; *e*, foramen stylo-mastoideum; *f*, fenestra ovalis; *g*, fenestra rotunda.

In the lower wall, if a section be made, it will be found more firm and compact than the upper one. In looking at the canal from without inward in its long axis, the surface is convex, the greatest elevation being at the borders of the inner third. Between this point and the lower attachment of the membrana tympani there exists a concavity, which often serves as a nidus for small foreign bodies (sinus of the external meatus, H. Meyer). There is a difference in the relative lengths of the superior and inferior walls; the former extends farther outward, but the latter approaches nearer the middle line of the body. This fact, together with the difference in the lengths of the anterior and posterior walls, explains the oblique position of the membrana tympani. The anterior wall of the osseous canal is thinner than the others. Its surface directed toward the lumen of the canal is also convex, the convexity being most marked at the boundary of the inner third. This bulging of the anterior and inferior walls is often so great as to prevent a view of the anterior inferior portion of the membrana tympani during an examination. The anterior wall of the osseous canal together with that of the cartilaginous meatus are in relation with the glenoid fossa; a blow upon the lower jaw may cause a fracture of the bony canal. The posterior wall, formed principally by the mastoid portion, though in part by the

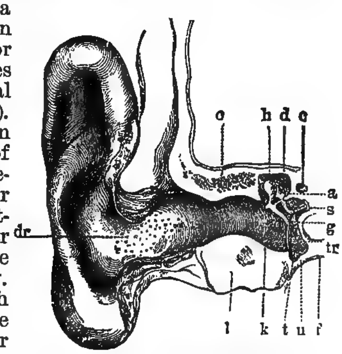


Fig. 351.—Vertical Section of the External Auditory Canal. *o*, Cellular spaces in the superior wall of the bony canal; *d*, superior wall of the tympanic cavity; *u*, inferior wall; *t*, tympanic cavity; *tr*, membrane tympani; *h*, head of malleus. *g*, handle of malleus; *a*, incus; *s*, stirrup; *c*, Fallopian canal; *f*, fossa jugularis; *dr*, openings of glands; *l*, inferior wall of bony canal.

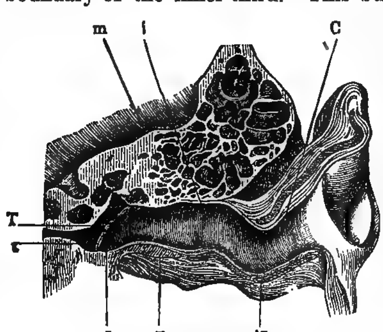


Fig. 352.—Horizontal Section of the External Auditory Canal. *c*, Concha; *i*, place of attachment of cartilaginous meatus; *m*, mastoid process; *v*, anterior wall of bony canal; *s*, sinus meatus auditorius externus; *t*, membrana tympani; *T*, tympanic cavity; *tr*, tragus.

tympanic portion of the temporal bone, extends farther outward than any of the other walls. The anterior wall, however, extends by seven to eight millimetres farther inward than the posterior. Inflammation of the mastoid cells may spread to the posterior wall of the canal: less frequently does the inflammation extend from the posterior wall to the mastoid cells.

According to Von Troeltsch, in every child from twelve to eighteen months of age there exists a foramen in the lower anterior wall of the osseous canal, due to irregularity in the growth of the bone at that point. It is about the size of a cherry-stone, and the period of closure varies; sometimes it occurs during the third year, and occasionally not till the child is quite grown. This opening is covered only by skin and periosteum, so that inflammation at this point could easily pass to the parotid gland. According to the same author, the external ear, tympanum, and Eustachian tube are all developed from the first and second branchial fissures, which accounts for the frequent coexistence of external and internal malformations. The palate and jaw are likewise developed from the first branchial fissure, a fact which explains why we often find in the same individual congenital malformations of the ear, lips, and palate.

The lining membrane of the cartilaginous canal is a continuation inward of the integument covering the auricle, and is from one to two millimetres in thickness. It is covered with hairs, and connected with the follicles are the sebaceous glands. In the osseous canal, the cutis is much thinner and more delicate. It is firmly joined to the periosteum, and forms linear-shaped papillæ, which may become hypertrophied during inflammation and give rise to polypi. The ceruminous glands (*glandulæ ceruminales*) are found in the subcutaneous tissue, close to the sebaceous glands. These glands are tubular, and similar to sweat-glands in other parts; they discharge their contents either directly into the meatus or into the upper portion of the hair-follicles. They are most numerous at the junction of the bony and cartilaginous canals. It was formerly thought that there were no ceruminal glands in the osseous canal, but, according to Von Troeltsch, they extend in the form of a triangle from the posterior superior wall of the cartilaginous portion into the bony canal.

The arteria temporalis superficialis sends several branches, arteriæ auriculares anteriores, to supply the outer portion of the auditory canal. The deeper portions receive their blood-supply from the arteriæ auriculares profundæ branches of the arteria maxillaris interna. These branches are distributed in the lining membrane about the glands of the hair-sacs and sebaceous glands. Several twigs pass along the superior wall of the canal to the membrana tympani, and thence along the handle of the malleus to its inferior extremity. The arteria auricularis posterior also supplies the canal.

The veins, *venæ ariculares anteriores et profundæ* join principally the vena facialis posterior: some of the veins of the meatus empty into the vena facialis, or as venæ posteriores into the vena jugularis externa.

But little is known of the lymphatics in the auditory canal. They are probably connected with the glands under the meatus and lying upon the parotid gland. The nerves supplying the auditory canal are the nervus auriculo-temporalis from the nervus inframaxillaris; the nervus auricularis magnus from the cervical plexus; also Arnold's nerve, *ramus auricularis vagi.*

According to Zaufal, in the new-born infant the membrana tympani rests with its whole surface on the inferior wall of the inner portion of the auditory canal. The canal, at this time, contains more or less vernix caseosa.

The diameter of the auditory canal is subject to great variations in different individuals. The cartilaginous canal at first gradually widens, then becomes narrow at the junction of the cartilaginous with the bony canal. In children, the canal is very small; while in old persons, there is often only a slit-like opening, as the anterior and posterior walls completely touch in some instances, due to atrophy and shrinkage of the cartilage. The osseous meatus is narrowest at the margin of the inner third (isthmus). From the latter point to the attachment of the membrana tympani it gradually becomes wider. Foreign bodies often become impacted at the isthmus. The distance from the isthmus to the anterior margin of the membrana tympani is 7 to 8 mm., while from the same point to the posterior margin, it is but 1 to 2 mm.

The transverse diameter of the osseous canal at the isthmus is 6 mm. At the inner and outer extremities, 9 to 10 mm. According to Von Troeltsch, the measurements of the entire auditory canal (bony and cartilaginous) are as follows: Superior wall, 21 mm.; inferior wall, 26 mm.; anterior wall, 27 mm.; and posterior wall, 22 mm. Average length of the canal, 24 mm.

The cartilaginous portion forms more than one-third of the whole. The general direction of the canal is sigmoid; it is somewhat curved upon itself, so as to be higher in the middle than at either end. The direction of the cartilaginous portion is backward and upward, while that of the bony is forward and downward.

According to Politzer, there are two points in the auditory canal of great importance in the reflection of the sound-waves upon the membrana tympani. One point is the depression on the posterior wall of the cartilaginous canal, commencing just inside the orifice, and extending along the posterior superior wall to the middle of the canal, and situated just opposite the cavity formed by the tragus. The second point is the concavity (sinus of the external meatus) situated on the anterior and inferior portion of the osseous meatus, and partly covered above by the membrana tympani. The waves of sound are collected by the first depression from the cavity formed by the tragus, and then reflected to the second point, and thence to the membrana tympani. The intensity of the wave-sounds is modified by the repeated reflection. A speck of blood on the dermoid layer of the auditory canal, if observed from day to day, will be seen to gradually move toward the external orifice. Burnett believes that the escape of cerumen from the canal is aided by this physiological process. *Gorham Bacon.*

AUDITORY CANAL, CONGENITAL DEFECTS, DISEASES, AND INJURIES OF. MALFORMATIONS.—Malformations of the auditory meatus are usually combined with congenital defects of the auricle and middle ear, sometimes with arrest of development of the bones of the head (Mich. Jaeger, Moos, Zuckerkandl, Steinbrügge, and others). Contractions of the canal, complete closure, osseous or membranous (congenital atresia), and entire absence of the auditory meatus, represent the three different degrees of congenital defect.

In place of the external orifice of the ear there may be shallow depression, or a short blind canal, or a very fine canal extending inward for some distance beyond the narrow, funnel-shaped cartilaginous portion. The canal may be uniformly narrowed throughout its extent, or constricted near its middle like an hour-glass, or the principal contraction may be near the membrana tympani. Congenital bridge-like bands of connective tissue crossing the meatus have been described by Moos ("Klinik der Ohrenkrankheiten," p. 85). Abnormal width of the meatus, amounting to deformity, is sometimes a congenital condition.

Some instances of *double* meatus are known, which are to be referred to an arrest in the closure of the first branchial cleft (Schwartze). In Velpeau's case one canal terminated at the drum-membrane; the other, situated further back, in the mastoid process; the two canals may also communicate before reaching the drum-head. Up to the fourth year of childhood an ossification gap exists as a normal condition in the anterior lower wall of the meatus (see Anatomy).

Congenital closure of the meatus, even when complete, is not incompatible with a useful degree of hearing, provided the development of the labyrinth be normal. Operative interference for the relief of congenital atresia is only justifiable when the closure of the canal can with certainty be proved to consist of a thin septum, when speech can be understood through the ear-trumpet ap-

plied to the closed part, and when the Eustachian catheter and otoscope have demonstrated the existence of a tympanic cavity.

Impacted Cerumen, Hypersecretion of the Ceruminal Glands.—The secretion of the ceruminal glands is, under perfectly normal conditions, probably never retained to the extent of impairing the function of hearing, but is gradually removed toward the exterior, and finds its way out of the ear, partly in consequence of the movements of the jaw, which are communicated to the meatus, partly from the natural outgrowth of the epithelium lining the meatus (Blake), and, finally, in consequence of certain manual operations. These processes are, however, not infrequently unavailing, and the cerumen remains in the meatus, forming a plug which blocks up the canal, and causes a mechanical impairment of hearing. An accumulation of cerumen is promoted in various ways: 1. In consequence of hypersecretion of cerumen, anything which induces persistent hyperæmia of the auditory canal may lead to this result; in some cases the cause of the hypersecretion cannot be recognized. 2. Contraction of the meatus, especially the well-known partially collapsed condition of the cartilaginous meatus incident to old age. 3. Abnormal nature of the secretion, which sometimes acquires a tough, adhesive property, and readily becomes matted with exfoliated epidermis and the hairs of the cutis. 4. Foreign bodies in the ear, forming a nucleus around which cerumen accumulates, until a plug is formed. 5. Misdirected efforts at cleansing the ears, commonly the introduction of moisture in washing the ears, followed by the insertion of a pointed piece of the towel, or, what is still more mischievous, the so-called aurilave or ear-swab.

It is well to remember that ceruminal plugs are frequently met with in persons suffering from chronic middle-ear disease. So long as even a small space remains free, ceruminal plugs do not materially interfere with the function of hearing; but if the plug presses upon the membrana tympani, or if it suddenly becomes swollen, as in washing, or from free perspiration, so as to entirely occlude the lumen of the canal, discomfort and hardness of hearing ensue; owing to this, the writer has met with impacted cerumen much more frequently in the months of July and August than at any other season of the year.

Symptoms.—Temporary attacks of deafness, coming on suddenly and lasting for a few hours or days, and as suddenly passing off, are a very common symptom of impacted cerumen. At such times there is apt to be a feeling of fulness and confusion with subjective noises in the ear, and a disagreeable resonance of the subject's own voice. Vertigo, mental depression, and neuralgic pains sometimes occur. When pain has been at all a prominent symptom, circumscribed excoriation or inflammation of the auditory canal or membrana tympani are not uncommonly found after removal of the accumulation.

Impacted cerumen never gives rise to total deafness. If in this condition speech cannot be understood, there is probably serious disease of the middle or internal ear. Complete occlusion of the canal, and contact of the plug with the membrana tympani, may, however, occasion great hardness of hearing, lasting in some instances for months or years, before efficient steps are taken for its removal. The presence of impacted cerumen alone probably never occasions serious injury to the walls of the auditory canal or membrana tympani. Enlargement or irregular dilatation of the meatus, with more or less destruction of the drum-membrane, belong to other morbid conditions—antecedent chronic suppuration, the formation of laminated epithelial plugs, a somewhat rare condition to be described presently.

Diagnosis.—In connection with the above-mentioned symptoms, the meatus is seen, by speculum or naked eye examination, to be plugged with a dull yellow, brown, or black mass with a dull or glistening surface. If touched with a probe the mass is found to be soft and sticky, doughy, or of stony hardness. Various foreign substances in the meatus, covered with cerumen, are apt to be mistaken for ceruminal plugs.

Cerumen is a saponaceous substance readily softened with warm water, but when combined with a large amount of epithelium, or when very much desiccated, the mass may present considerable resistance to the action of water. After the removal of impactions of long standing, the inner extremity of the mass may present a tolerably perfect impression of the membrana tympani.

Treatment.—All that is usually required is a syringe and warm water; the use of scoops, probes, curettes, and forceps, is to be avoided except under good illumination, and only then by persons thoroughly skilled in the manipulations of aural surgery. If on examination the occluding mass be found dry and firm, it will be well to make several instillations of a warm solution of carbonate of soda in glycerine and water the day previous to syringing, or if this does not suffice to soften the plug, continue the instillations for a day or two longer, because harm may be done by long-continued or too forcible syringing. To syringe the ear effectually, a large vulcanite syringe should be used capable of containing at least two ounces, and provided with a ring for the thumb on the end of the piston-rod, and a flange for the fore and middle fingers at the heel of the syringe. The small vulcanite syringes, sold in the shops for ear-syringes, are very inefficient, and cheap glass syringes are simply useless for this purpose.

In syringing, the patient's head should be held erect, the clothing protected with a towel, and a vessel such as a glass finger-bowl rested against the integument below the auricle. In order to throw a stream of water effectively into the auditory canal, the general inward, forward, and downward direction of the canal must be made uniform by exercising gentle traction of the pinna with the left hand in a direction upward and slightly backward. The point of the syringe, which should be rounded and smooth, but not so large as to fill the orifice of the meatus, should be lightly rested against its upper margin and pointed in the same direction as that of the auditory canal. If these precautions are observed, the stream of water will pass along the upper wall of the canal and force the obstruction out below the point of the syringe. From one to four injections will ordinarily suffice to remove the impaction. After two or three injections, it is often advisable to examine the ear and, if necessary, move the mass a little with the end of a probe to facilitate its removal with the syringe and water.

In otherwise healthy ears, the function of hearing is, as a rule, restored immediately by removal of the ceruminal accumulation, and the subjective noises cease; occasionally, several days elapse before a feeling of perfect relief is obtained. After syringing, the meatus should be lightly closed for a few hours, with cotton-wool. A recurrence of the ceruminal accumulation may be expected to take place after an interval of several months or years, occasionally at intervals of a few weeks.

A want of ceruminal secretion, with undue dryness of the ears, is usually symptomatic of chronic middle-ear disease; if attended with itchiness, painting the meatus with some softening substance, such as vaseline, affords relief.

Laminated Epithelial Plugs (*Keratosis obturans*, Wreden, Burnett).—Occasionally, the meatus is found obstructed with a mass which at first sight resembles an ordinary ceruminal plug, but the use of the syringe only brings away a small quantity of cerumen, without relieving the deafness, which in these cases has commonly been of long duration and high degree. An examination now shows the meatus to be filled with a tough adhesive substance of lighter color than ordinary cerumen. The continued use of the syringe is fruitless, but crumbling fragments of the partially softened mass can be removed with curette or forceps. The removal of this form of obstruction is tedious and difficult, on account of its cohesive properties and close adherence to the walls of the canal; small fragments may be detached and brought away by the use, from day to day, of the syringe, blunt probe, and forceps, and in the intervals repeated instillations of warm alkaline solutions. The writer has seen several cases in which this plan of treatment had to be

pursued for four or five days before the accumulation was all removed, and in every instance the auditory canal was found more or less eroded and irregularly excavated, probably from pressure of the mass.

The term laminated epithelial plug indicates the composition of the obstructing substance, which appears to be formed by the gradual accretion of epithelial laminæ, derived from the horny elements of the cutis lining the external auditory canal, the result probably of a chronic inflammatory process in this situation. A recurrence of the obstruction may be avoided by suitable treatment of existing inflammation and by the early removal of any commencing accumulation. This disease of the external auditory canal is analogous to, if not pathologically identical with, the so-called cholesteatoma of the temporal bone, which originates in the tympanic cavity and mastoid antrum, in consequence of chronic desquamative inflammation of these parts.

Parasitic Inflammation of the External Auditory Canal (*Otomycosis, Myringomycosis Aspergillina*).—A definite knowledge of this subject is of comparatively recent date. Isolated observations of vegetable fungi growing in the living human ear were made by Mayer in 1844 (Müller's *Archives*, p. 401); Pacini in 1851 (supra, "Una muffa parasita (mucedo) nel condotto auditivo esterno," Firenze, p. 7); Carl Cramer in 1859 (Vierteljahrsch. d. Naturf. Ges. in Zürich), and by Schwartze in 1867 (*Arch. für Ohrenheilk.*, Bd. ii., p. 5). Wreden's publication of six cases of *Myringomycosis* (*Arch. f. Ohrenheilk.*, Bd. iii., p. 1), followed by his Monograph in 1868, drew the attention of otologists generally to this peculiar form of disease.

Since this time numerous observations of a similar kind have been made both in Europe and America, and the existence of several species of parasitic aural fungi demonstrated. The fungus most commonly met with in the ear is the Aspergillus, several species of which have been described by otologists; these are the A. nigricans, A. flavus, and A. fumigatus; some doubt, however, still prevails as to whether the two latter are not merely accidental modifications of the Aspergillus glaucus. The fungus is found under the microscope to consist of four distinct elements: (1) Mycelium, a network of filaments, tubules, or rootlets; (2) the fruit-stalk or hyphen; (3) the fruit-head or sporangium; (4) the conidia or free spores.

The mycelial filaments or tubules consist of pale, transparent, straight or curved, branching, double-contoured fibres, which are divided at irregular intervals by transverse septa; they, as well as the fruit-stalks, contain a faintly granular plasma. Their diameter varies from 0.0038 to 0.005 of a millimetre. The fruit-stalks are considerably thicker than the mycelium, varying in diameter from 0.009 to 0.013 mm. Their length is from 0.3 to 0.8 mm. The terminal bulbous enlargement, called the receptaculum or sporangium (the placenta of Micheli), is about 0.028 mm. in diameter, and bears upon its surface a large number of long radiating cells (sterigmata), from the free ends of which grow the round spores or conidia, the whole forming the so-called capitulum or fruit-head. The spores are spheroidal, smooth, or echinate, exceedingly numerous, and very small, about 0.003 mm. in diameter; their color determines that of the fruit-head, and is black-brown in A. nigricans, yellow or greenish in A. flavus or A. glaucus, and grayish-black in A. fumigatus.

According to Siebenmann (Die Fadenpilze, Wiesbaden, 1883) the distinctive features of the fruit-bearing portions of A. flavus, A. fumigatus, and A. nigricans are as follows:

A. flavus. Fruit-stalk firm, colorless, somewhat roughened, increased in thickness just below the head, 0.4 Cm. in length, 7 to 10 μ in diameter, fruit-head loosely formed, of a golden yellow color. Sterigmata undivided, usually only found on upper half of receptaculum, conidia sulphur-yellow or brownish in color, round or oval, surface echinate.

A. fumigatus. Fruit-stalk short and delicate, 5 μ in diameter, and shaped like a reversed ninepin at its free extremity; sterigmata undivided, elongated, spring only from the convex extremity of receptaculum; the latter is occasionally spheroidal, or long, oval in shape. The fully-formed fruit-head is never globular, its color is yellow or greenish-gray, conidia round or oval, smooth, and pale.

A. niger. Fruit-stalk 8 Mm. in length, thick and strong, of uniform width throughout, contains a somewhat granular dark-colored plasma, of a deeper shade toward the receptaculum; its diameter is about 10 to 15 μ; sterigmata 20 to 100 μ in length, of a brown color, larger toward distal extremity, where they apparently subdivide into from three to eight prolongations. Conidia blackish-brown in color, smooth or echinate, and very numerous. The fruit-heads of A. glaucus are smaller and narrower than those of A. nigricans (Burnett, *Am. Jour. of Otology*, 1879). The sporangium of A. fumigatus is, according to Bezold, still smaller than these.

If we exclude the *Otomyces Hageni*, of Hagen and Hallier, the Graphium pencilloidis of Hassenstein and Hallier, and the Penicillium of Blake, on account of their having been obtained by culture from substances of doubtful nature taken from the ear, there are still four varieties of aural fungi to be mentioned. They are: 1. *Tricotheceum roseum*, of Steudener (*Arch. f. Ohrenheilk.*, Bd. v., p. 163), and *Mucor mucedo s. fuscus*, of Böke (*Hungarian Med. Chirg. Press*, 1869—9,—12, 16, 19), both varieties of doubtful identity. 3. Ascophora elegans of Von Troeltsch ("Die Myringomycosis," p. 44). 4. *Otomyces purpureus*, of

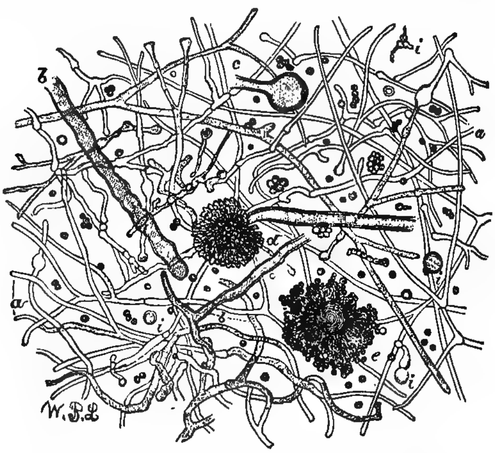


Fig. 353.—Aspergillus Niger. (From Roosa.)

Wreden (*Arch. of Ophth. and Otology*, vol. vi., No. 1, p. 87). The last-named fungus has also been once observed by Burnett (*Arch. of Otology*, vol. x., No. 4, p. 319). In Wreden's case the false membrane also contained spots of Aspergillus nigricans, and he was led to believe the O. purpureus represented *the ascomycete of the Aspergillus nigricans, that is the highest form of the specific aural fungus.* Burnett, however, found no evidences of such relationship in his case, and regards the *O. purpureus* as a species *sui generis.*

All the conditions requisite for the growth of aural fungi are not yet fully understood, but since attempts to cultivate the growth in the healthy human ear have uniformly failed, it seems probable that the presence of certain pathological changes, attended with undue moisture or a softened and loosened condition of the epithelial lining of the meatus, are essential to the development and growth of the fungus in the ear. The age and hygienic surroundings of the patient, climate, and season of the year, are not without influence. The Russians, living as they do in artificially heated and badly ventilated dwellings during the long winter season of that climate, seem especially liable to otomycosis. The poorer classes, who live in damp apartments, are said to be more frequently affected than those whose circumstances are more fortunate. If this be true, the comparative immunity of the English people, notwithstanding the dampness of their climate and the large pauper population, is somewhat remark-

able. In Germany and the United States the disease is by no means rare, but in the Province of Quebec the writer has only met with one example of aural fungus among three thousand five hundred patients. This case was of A. nigricans, occurring in a youth fifteen years of age, the son of a wealthy merchant, and is all the more remarkable because young people are seldom affected in this way. This patient came under notice again about a year later, on account of a slight diffuse otitis externa without any recurrence of the fungus.

The disease is prone to occur in already diseased ears, but is seldom or never found in the presence of an active purulent otitis. Substances which readily undergo decomposition, such as fats and oils, instilled into the ear, are said to favor the development of Aspergillus. The presence of normal ear-wax is unfavorable to its development. There can be little doubt that this affection was formerly often mistaken for impacted cerumen, or for ordinary otitis externa diffusa. The fungus usually originates in the deeper portions of the auditory canal and upon the membrana tympani, hence the name myringomycosis. The irritation which it causes may induce ulceration of the membrana tympani and an extension of the fungus to the tympanic cavity; but when the new growth is met with in this situation an exhausted suppuration, with perforation of the membrane, has usually preceded the development of the fungus.

Symptoms.—Fungus growths in the external meatus and tympanic cavity may exist for a considerable time without exciting any troublesome irritation; according to Bezold this is especially true of the A. fumigatus. Sooner or later, however, the form of inflammation known as otitis externa parasitica sets in. This results from the fungus having penetrated the epidermis and reached the living tissues (Politzer), or in consequence of irritant qualities of the fermentation products to which the growing fungus gives rise (Siebenmann).

The subjective phenomena of parasitic otitis are itching of the meatus, lancinating pains, and a feeling of fulness in the ear; tinnitus is usually present, vertigo rarely so; the impairment of hearing is often considerable. On examination the walls of the meatus and the membrana tympani are seen to be partly or completely hidden by a membranous substance of a dull whitish, yellowish, or blackish color. In O. purpureus, the meatus has been found occluded with a red substance resembling blood-clot, and in A. flavius it is spoken of as containing a yellow dustlike substance, like pollen dust. There is often a watery discharge from the ear. When the ear is syringed, shreds of membrane resembling wet paper may be removed; sometimes the aid of forceps is required. The fruit-heads of the fungus are visible to the naked eye, as black or yellow dots on the surface of the false membrane; the microscope will readily show their peculiarities of structure. When the fungus is removed, the auditory canal is found to be more or less reddened and tender; if no other measures are resorted to, the growth may be reproduced in a few hours.

The *prognosis* is favorable in all varieties of otitis externa parasitica, as there is no difficulty in destroying the growth by the use of suitable remedies, and thus effecting a speedy cure. Fresh attacks may occur if the surroundings of the patient remain the same.

Treatment.—Of the many remedies recommended for the destruction of the fungus, alcohol is probably the best. The ordinary spirits of wine may be used. After removal of the casts with a syringe and warm water, the meatus may be filled with warm spirit, which should be allowed to remain in the ear for ten or fifteen minutes; this may be repeated twice daily for several days. The spirit may be diluted if it causes pain, and gradually increased in strength if necessary. Three or four days of this treatment will suffice to effect a cure. To prevent relapses, Politzer advises the occasional use of the spirit for at least a year; this precaution, however, will seldom be necessary.

Many other remedies have been found sufficiently effective; repeated syringing with warm water would probably suffice, though not so rapidly as when combined with the use of some parasiticide. Wreden extols the use of chlorinated lime (0.07 to 0.15 in 35.0 aq. dest.), Blake and Burnett, the hyposulphite of soda (0.2 in 30.0). Boracic acid in powder, alone or with an equal quantity of oxide of zinc (Theobald), or in alcoholic solution (1 in 20); permanganate of potassium in one to two per cent. solution (v. Troeltsch *et al.*); carbolic acid in glycerine (3 in 100, Lucae); salicylic acid in alcoholic solution, two per cent. (Bezold); bichloride of mercury in water (1 to 500), and various other remedies, are mentioned by different observers. Painting the meatus with strong solutions of nitrate of silver is found beneficial if inflammation persists after removal of the fungus (Roosa). If the affection be complicated with middle-ear disease, this too will require appropriate treatment.

Pityriasis alba of the external meatus has been described by Ladreit Lacharrière ("Annales des Maux de l'Oreille," 1875) as a rare form of mycosis, for which the treatment is extraction of the stiffest hairs and painting the meatus with a one per cent. solution of corrosive sublimate.

DIFFUSE INFLAMMATION (*Otitis Externa Diffusa*).—Diffuse inflammation of the external auditory meatus is either acute or chronic, primary or consecutive. The consecutive form occurs in connection with inflammatory affections of the middle ear, and is subordinate to the deeper-seated disease. As a primary affection, diffuse inflammation is rarely of idiopathic origin, but may usually be traced to the instillation of irritating substances, or to mechanical and traumatic causes. The lining of the osseous section of the canal is the part chiefly affected though the membrana tympani and the outer portion of the meatus may become involved.

Symptoms.—The acute form of the disease begins with itching sensations in the ear, followed by a feeling of fulness and heat. Pain of moderate or intense severity occurs early, and is always increased by pressure on the ear and by movements of the jaw. Tinnitus and giddiness are sometimes complained of. The impairment of hearing is slight, except when the membrana tympani is considerably swollen and the auditory canal contains a sufficient quantity of secretion and exfoliated epithelium to obstruct its lumen.

The objective signs are a whitish exudation lining the walls of the canal, consisting mostly of exfoliated epithelium, often of a pasty consistence from admixture with viscid secretion; sometimes of a continuous pouch-like membrane. After syringing, the meatus is found more or less narrowed from swelling, especially of its deeper parts, and at the same time reddened and sensitive. The line of demarcation between the meatus and membrana tympani, as well as the usual anatomical features of the latter, may be obliterated by the swelling and uniform redness of these parts; occasionally the meatus is so contracted by diffuse swelling, that a view of the deeper parts is impossible. The writer once observed a case of diffuse otitis externa, occurring in a profoundly hysterical subject, which was characterized by attacks of intense pain followed in a few hours by the formation of large blebs containing serous exudation of a pale yellow color; in this way the entire epidermis of the meatus, and probably of the membrana tympani, was several times thrown off, leaving a moist, not swollen, but reddened and intensely sensitive surface, which speedily became covered after each attack with normal epidermis. With the cessation of the recurring inflammation, complete anæsthesia of the meatus and membrana tympani supervened, also sudden and total deafness lasting for several months.

The acute form of otitis externa diffusa usually subsides under proper treatment in the course of a few days; in less favorable cases there may be relapses of the inflammation, ulceration of the meatus or membrana tympani, and the formation of polypoid growths.

In chronic diffuse inflammation there is little or no pain, but more or less itchiness with scanty discharge, often of a fetid character. If the latter symptom is conspicuous, careful examination should be made for other evidences of chronic mastoid disease. Suspicious-looking flakes or casts should be examined for fungous growths.

In any case, the possible consecutive nature of the disease should be held in view, and the diagnosis not considered complete until proper steps have been taken to prove the non-existence of deeper-seated disease.

The *prognosis* of uncomplicated otitis externa is favorable in all its forms.

Treatment.—While the acute symptoms last, leeches, anodynes, scarification of the inflamed parts, and warm-water irrigation are in order. If the disease be of traumatic origin, continuous applications of cold compresses to the region of the ear are serviceable. Leeches when applied should be placed in front of the tragus. Scarifications are only to be made in the early stage before exudation has occurred. The incisions should be three-fourths of an inch long in the walls of the canal (Gruber). For warm-water irrigation, the fountain syringe, or some form of continuous aural douche, may be employed. Anodyne instillations of solutions of morphia or atropia may be used; in childhood the latter cannot be used with too much caution, especially if the drum-membrane is perforated.

Poultices should not be applied for more than two or three hours consecutively, on account of their tendency to promote the formation of polypoid growths.

In all chronic cases, repeated cleansing of the ear with warm-water irrigation is indispensable. Insufflations of boracic acid powder, after the canal has been cleansed, often act like a charm, and may be employed even in acute cases, when discharge has set in. This may be repeated whenever the powder has become moist. Strong solutions of nitrate of silver are often very useful, but must be avoided so long as there is pain. In some chronic cases the insertion of a plug of cotton-wool, smeared with diachylon ointment, effects a speedy cure (Buck, Roosa). In these cases the disease has probably been of an eczematous character.

Acute Circumscribed Inflammation of the External Auditory Meatus (*Follicular Inflammation, Furuncles, Boils, Otitis Externa Circumscripta*).—This form of inflammation seems to have a special predilection for the external auditory canal, having its seat chiefly in the cartilaginous portion. The disease is quite common in adults, rare in childhood, and seldom or never met with in infancy. It is said to occur with special frequency in spring and autumn, sometimes as an epidemic, and sometimes associated with a more general furunculosis. Anæmia, disorders of menstruation, diabetes mellitus, and change of life are said to predispose to auditory furuncles. Strong and otherwise healthy persons are by no means exempt from it, but debility induced by an unhealthy mode of life, or by living in badly ventilated houses, seems to exert a predisposing influence.

As local causes may be mentioned: chronic discharges from the ear, chronic eczema of the meatus, mechanical irritation, such as may be caused by the presence of foreign bodies, frequent syringing, scratching the meatus with hard instruments, such as hairpins and toothpicks; irritating medicinal applications, and the use of alum lotions. The sebaceous and ceruminous follicles are probably the starting-point of the inflammation; occasionally it originates more deeply, in the perichondrium, or in the substance of the cartilage (Buck).

The pus of aural furuncles has been found loaded with micrococci (Löwenberg), and it is not unreasonable to suppose that furuncular inflammation may originate from these having found their way into the glandular follicles from the air, or from the water used in syringing; in any case, moisture would favor their rapid development, and this may be the reason that syringing the ear is apt to excite furuncular inflammation.

Symptoms.—If the inflammation is superficially situated, the pain is usually slight; if the inflammation is deep-seated, the pain may be very severe, of a tearing or beating character, and radiating to other parts of the head and neck. It is intensified by traction of the auricle and by movements of the jaw. Hardness of hearing, a feeling of fulness, and tinnitus are complained of in some instances, especially when the meatus is much obstructed by the swelling, which always involves the cartilaginous portion of the meatus, and is usually most marked in its anterior inferior wall, near the tragus, because the disease attacks this part most frequently. Sometimes the tissues behind or in front of the ear are swollen and the skin reddened.

Superficial furuncles appear more or less red from the outset; when they are deep-seated, the redness is not present until the abscess approaches the surface. Febrile symptoms may be present in the severer cases. Tenderness over the inflamed centre is a constant symptom; several furuncles may occur at the same time, or follow each other in rapid succession. Repeated attacks are not uncommon.

Resolution of the inflammation without suppuration seldom occurs. If the disease is left to nature, rupture of the abscess will take place sooner or later, often not for many days if the disease is deep-seated. After rupture of the abscess the swelling and pain quickly subside. Polypoid granulations requiring removal may develop from the point of rupture. The locality of the swelling and tenderness, together with the absence of symptoms indicative of deep-seated disease, render the diagnosis a matter of no difficulty. The presence of an exostosis covered with inflamed cutis, or bulging of the posterior wall of the meatus from mastoid disease, might be mistaken for furuncular inflammation, but could not deceive a careful observer. Inflammation of the deeper portions of the meatus in which glandular elements are wanting is not furuncular.

Treatment.—Measures must be employed to allay pain, shorten the duration of the disease, and prevent relapses.

The first two indications are best fulfilled by an early and sufficiently free incision or incisions through the swollen and tender parts. If pus is reached and evacuated, relief is quickly obtained; in any case the incisions promote an earlier discharge of the pus from the focus if the disease is deep-seated, and by relaxing tension tend to allay pain. The incision of deep-seated aural furuncles is horribly painful unless an anæsthetic be used; a small quantity of ether inhaled while the patient sits in a chair, will suffice to render the operation painless, as it can be done quickly in the first stage of anæsthesia. A four per cent. solution of cocaine will be found useful in allaying pain and may render the use of an anæsthetic unnecessary when an incision is required.

After the incision a warm-water douche may be used frequently, and the auditory canal cleared occasionally with a swab of absorbent cotton, care being taken not to irritate the parts by harsh manipulation. Leeches are of little or no use in this form of ear disease. Other measures for the relief of pain are, warm anodyne lotions by instillation or by means of saturated cotton-wool plugs. Such lotions may be made by adding liquor atropiæ to Magendie's solution of morphia, or extract of opium to water (1 to 3). Poultices afford great relief to some patients, and may be used either before or after incision; so also does warm water dripped from a sponge into the ear. The use of antiseptics is highly recommended by Politzer in the treatment of aural furuncles. The meatus may be painted several times daily with carbolic acid in glycerine (1 to 30), or boracic acid in alcohol (1 to 20), either before or after incision; in the first instance to abort the disease, in the second to prevent relapses. Smearing the meatus after incision with iodoform ointment (iodoform, 1.0; vaseline, 12.0) is believed by the writer to be of great service in preventing relapses.

The sulphide of calcium, Fowler's solution of arsenic, iodide of potassium, and other remedies given internally, have been recommended by several otologists of repute, but their actual value has not yet been sufficiently established to warrant more than a passing mention. Change of air may be advisable if the disease is protracted by repeated formation of furuncles and the patient's sanitary surroundings are obviously insalubrious. Errors of diet and all the recognized exciting causes should, as far as possible, be avoided.

Diphtheritic Otitis Externa occurs but rarely, and then almost always as a complication of scarlatinous diphtheritis of the throat and middle ear (Politzer). Pri-

Auditory Canal.

mary diphtheritis of the meatus has been observed during epidemics of diphtheritis; only in a few instances inflammation or excoriation of the meatus has pre-existed.

A false membrane of a dirty white color and firmly adherent to the walls of the meatus, is characteristic of diphtheritic otitis externa; when the membrane is forcibly removed, the exposed parts are found tender to the touch, excoriated, ulcerated, and bleeding. Severe pain, a feeling of fulness, tinnitus, and deafness only occur in the primary form of this disease; when it is associated with diphtheritis of the throat and middle ear, there is little or no pain, but there may be anæsthesia of the parts around the ear (Wreden, Wendt, Blau). Primary diphtheritic otitis externa usually terminates in recovery without injury to the ear. The consecutive form is apt to result in destructive ulceration of the membrana tympani, exfoliation of the ossicles, and caries more or less extensive of the temporal bone.

The *treatment* of diphtheritic otitis externa should be antiseptic. Lime-water instillations, followed by syringing with solution of boracic acid, will favor separation of the membrane (Burkhardt-Merian). After syringing, the meatus may be filled with powdered boracic acid; carbolic glycerine (1 in 15), carbolic spirit (1 in 20), solution of boracic acid in spirit (1 in 20), may be painted over the affected parts if the membrane, after being once detached, tends to form again. Forcible detachment of the membrane is injurious.

Syphilitic Affections of the Meatus are probably always associated with other manifestations of syphilis. The meatus may participate in any form of general cutaneous syphilis. Syphilitic ulcers and condylomata have been accurately described by many writers on aural surgery. Condylomata begin with reddish efflorescences in the meatus, followed by diffuse swelling and moderate secretion upon the parts so affected; the characteristic ragged, grayish-red, warty excrescences soon appear, and extending inward close the lumen of the meatus (Knapp, *Zeits. f. Ohr.*, vol. viii.). The disease is painless at first, but when the condylomata have formed, violent pain and deafness, etc., from mechanical obstruction supervene. They may undergo resolution, or may result in extensive ulceration, with fetid discharge.

Syphilitic ulcers in the meatus, with deep base and steep elevated margins, occurring in connection with syphilitic lesions of the nose, pharynx and cervical glands, have been described by A. H. Buck, Politzer, and others, and successfully treated by suitable local and constitutional remedies.

Cutaneous Diseases of the External Auditory Canal.—The cutis of the external auditory canal is not exempt from invasion by any of the general cutaneous diseases, the presence of which, upon the auricle or other parts of the integument, will afford the key to the diagnosis of such affections occurring in the meatus. Eczema, both in its acute and chronic forms, is a very common affection of the meatus. The integument of the auricle is, as a rule, more or less involved, in which event the diagnosis is sufficiently simple (see Diseases of the Auricle); when, however, the disease is limited to the meatus, it may not be possible to distinguish it from other forms of diffuse otitis externa.

Exostoses and Hyperostoses of the external auditory canal are not of infrequent occurrence. They are congenital or acquired, and may be single or multiple, spongy or eburnated, pedunculated or with broad base. Their favorite situation is at the outer portion of the osseous meatus, or at its inner extremity, close to the membrana tympani. Occasionally they entirely close the lumen of the meatus, but only in this event, or when the already narrowed meatus becomes blocked with secretion, do they cause much disturbance of hearing. This is the more likely to occur because their presence readily gives rise to inflammation of the lining of the meatus. Exostoses are often bilateral, and much more frequent in the male than in the female sex. The causes of acquired exostoses are doubtful. Rheumatism, arthritis, and syphilis are spoken of as constitutional causes, but these tumors are often hereditary, and unassociated with any of these conditions. Among the aborigines of America they seem to occur with special frequency. Local processes involving chronic hyperæmia of the auditory canal seem to predispose to their development. When they co-exist with chronic suppuration of the middle ear their presence forms an additional source of danger by favoring retention of pus. Fig. 354 gives a good idea of the appearance presented by multiple exostoses. They usually appear as white or yellowish smooth prominences, and when examined with a probe are found to be exceedingly firm to the touch; this feature serves to distinguish them from all other pathological formations in the meatus, even when the skin covering them is red and inflamed.

Small exostoses may last a lifetime without detriment to the subject, but larger osseous growths are apt to excite irritation by pressure upon the adjacent parts, and certainly favor the accumulation of cerumen, epidermis, etc.

Treatment.—Medication, local or general, with a view to procuring absorption, is useless; when of small size they should not be interfered with. If chronic suppurative disease of the tympanum is present it should if possible be healed; if this is impracticable, the auditory canal must be kept scrupulously clean. An accumulation of secretion beyond the growths may, with care, be removed, even through a small aperture. The offending substance may, if necessary, first be softened, by injecting a few drops of warm solution of carbonate of soda (1 in 20), through an ordinary Eustachian catheter, the point of which is pushed into the aperture; then, on the following day, free injection of warm water through the same instrument will probably bring the accumulation away. Dilatation of the strictures with metal plugs may be tried, and when perseveringly used has been found to enlarge the aperture sufficiently to restore good hearing (Bonnafont). When the narrowing of the canal is too great to admit of this, and there is great deafness and deep-seated pain, indicating pressure from retained secretion, surgical removal of the growth may become imperative, or a counter-opening may be established in the mastoid process, extending down to the antrum.

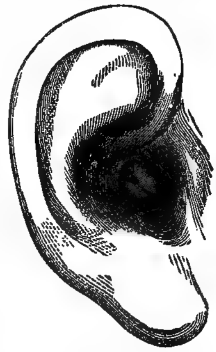


Fig. 354.—Exostoses of the Meatus. (From Welcker, "*A. f. O.*," i., Table 2, Fig. 7.)

The operation of removing such exostoses has been performed successfully with gouge and mallet, but is rendered difficult and tedious by bleeding, which obstructs the necessary view of the parts. The dentists' drill may be used with greater precision, and is, therefore, a better method of performing the operation. Dr. Mathewson, who first performed this operation, relieved his patient permanently by drilling an aperture rather more than three millimetres in diameter through the bony obstruction ("Report of the First International Otological Society," p. 86. New York: D. Appleton & Co., 1877). The galvano-cautery has also been used successfully (Voltolini, Delstanche), but this procedure is difficult and tedious.

The choice of operation, whether the removal is to be partial or complete, must depend partly upon the surgeon's judgment and partly on the peculiarities of the case.

Absence of the Meatus.—Occasionally the meatus is found terminating as a smooth, cutaneous cul-de-sac, without any appearance of a tympanic membrane; the canal, under these circumstances, being shorter than normal, smooth and pale. This condition results from ulcerative inflammation of the meatus, with immediate contact of its walls, or their union by granulation tissue. The atresia may be osseous or fibrous, and may consist of only a thin septum, or of a long mass of osseous or connective tissue. In the former case the fundus of the cul-de-sac is found to

be yielding and elastic. If, under these circumstances, bone conduction shows a normal condition of the internal ear, the septum may be divided or partially excised, and a permanent opening secured by the introduction of leaden pegs, which must not be removed until healing has taken place. Politzer relates a case of this kind, in which he obtained great and permanent improvement in the hearing.

POLYPI.—The development of pedunculated connective-tissue growths in the meatus is a common sequence of neglected chronic suppuration of the middle ear. Under these circumstances such growths usually originate from some part of the tympanic mucous membrane, less frequently from the covering of the ossicles, or from the membrana tympani. Polypi may also develop from the lining of the meatus, their point of attachment commonly being the posterior or superior wall, near the membrana tympani, rarely from a more external part of the auditory canal. Springing from the meatus they are, oftentimes, the result of prolonged and injudicious poulticing.

Aural polypi are usually single; several may, however, grow simultaneously in one ear. Their surface is smooth or finely lobulated, and always covered with epithelium. They are sometimes large enough to fill the meatus, and even project for a short distance beyond the external orifice; others, again, do not exceed the size of a pea. When they are small their shape is globular, pear-shaped, or elongated when so large as to be moulded by the meatus.

Four varieties of aural polypi have been recognized:

1, Mucous polypus; 2, fibroma; 3, myxoma; 4, angioma.

Of these, the mucous polypus is by far the most common, though fibromata are by no means rare. Myxoma has been described by Steudener (*Archiv f. Ohrenheilkunde*, Bd. iv., p. 203), and angioma by Dr. A. H. Buck ("Transactions of the American Otological Society," 1870).

Histology.—The mucous or round-celled polypi, developed from the tympanic mucous membrane, represent essentially a hyperplasia of that structure, and are exactly similar in structure to the mucous polypi developed from other mucous cavities. Polypi which spring from the meatus, however, are covered with pavement epithelium, and contain neither glands nor cysts, like the polypi of the middle ear, although, like these, they may have a papillary structure (Schwartze). Aural fibromata are similar in structure to the naso-pharyngeal fibromata which develop from the periosteum of these parts. They are smooth, dense, firmly attached, of a pale color, and always covered with a multiple layer of pavement epithelium. Tubular glands and cysts are wanting in these growths. Their structure is made up of firm connective tissue, with numerous spindle- or star-shaped connective-tissue corpuscles, the processes of which anastomose with each other. The intercellular substance is homogeneous, and contains fibrillæ arranged in interlacing bundles.

For a description of aural myxoma and angioma, the reader is referred to the articles mentioned. A few cases have been recorded in which a partial ossification of aural polypi had taken place (Bezold, Cassells).

Diagnosis.—Suppurative disease of the ear always coexists with polypi, and more or less extensive destruction of the membrana tympani is commonly present. Soft polypi may develop rapidly; fibromata are of slow growth. Either variety may persist for a lifetime without injuring health. The mechanical obstacle which they present to the escape of the secretion may cause pain or a feeling of heaviness and pressure in the affected side of the head, with or without giddiness and tinnitus. The stagnation of secretion may lead to cheesy accumulations and caries of the temporal bone, with all its disastrous consequences. The spontaneous death and discharge of polypi is of rare occurrence. The diagnosis of aural polypi presents no difficulties. Simple inspection will suffice to determine their presence. Malignant new formations, springing from the same parts, may possibly lead to an erroneous diagnosis. Careful exploration of the meatus with a blunt probe will often enable the surgeon to determine the point of attachment of the polypus. According to Politzer, pale-red, or pearl-gray polypi, with a smooth or moderately rough surface, spring usually from the meatus; while the sodden, red, vascular, raspberry-shaped growths with villiform papillated surfaces, most frequently arise in the tympanic cavity.

The *prognosis* is generally favorable, especially in the case of polypi which spring from the meatus, their thorough eradication being less difficult than when the growth originates in the less accessible tympanum. Large polypi, of course, always act as mechanical impediments to hearing, and their removal may be followed by great improvement in the hearing power; the prognosis, however, must be guarded in this respect, even when there is reason to believe that the condition of the internal ear is normal, since the physical conditions in the middle ear may render a restoration of the hearing impossible.

Treatment.—Removal of polypoid growths is always advisable; this may be accomplished in various ways. When the fact can be established that the growth springs from the walls of the meatus, its extraction by means of Wilde's snare may be undertaken. The loop of the snare should be tightened around the pedicle of the growth, close to its insertion, and the operation should be completed by traction, or, if a moderate amount of traction will not suffice, ligature of the polypus may be effected by rotating the instrument on its long axis until a greater resistance is felt; then the wire is cut loose from the cross-bar and the instrument removed, leaving the twisted wire loop around the pedicle, and thus causing strangulation and death of the growth.

If there is a probability that the growth springs from the membrana tympani, or from the tympanic cavity, it should be *excised* as deeply as possible, with the instrument known as Blake's modification of Wilde's snare, traction not being admissible on account of the damage that might accrue to the drum-membrane. Politzer's annular knife is also a valuable instrument for the excision of polypi. Small pedunculated growths may sometimes be crushed, or removed with suitable forceps, or with one of Buck's loop curettes.

The galvano-cautery may be used with advantage for the removal of large, firmly attached fibroid polypi, also for cauterizing granulations and the remnants of polypi. Its use is said to be followed by less inflammatory reaction than is observed after the employment of caustics. Granulations in the meatus or tympanum and the remains of polypi may be treated with various caustics; strong solutions of nitrate of silver, forty grains to the ounce and upward, are often very serviceable, but not for the remains of polypi; chloro-acetic, nitric, and chromic acids, persulphate of iron and acid nitrate of mercury have been used with excellect effect, but require great care in their application, which must be strictly limited to the diseased structures which it is intended to destroy. Politzer and others strongly recommend alcohol in the form of rectified spirits, or stronger alcohol, as a remedy for the removal of granulations and aural polypi. It should be employed in the following manner: The ear must be first carefully cleansed, and dried out with absorbent cotton. The spirit should then be warmed before it is poured into the ear, where it should be allowed to remain for fifteen minutes or half an hour. The application of this remedy must be repeated two or three times daily. It is claimed for this mode of treatment, that it will cure not only granulations and the remains of polypi after operation, but that it will cause large and even fibroid polypi to shrivel and become absorbed, thus in a large number of cases doing away with all necessity for operative interference. To prevent the recurrence of polypi after their removal, any existing ulcerative or suppurative process must be treated upon the principles laid down elsewhere until the parts have been restored to a healthy state.

Other morbid growths, more or less malignant in character, are occasionally met with in the external auditory

canal. Enchondroma originating in the cartilage of the meatus has been described by Launay (*Gaz. des Hôp.*, 1861). Osteoma in the mastoid process, which projected into and caused closure of the meatus, is mentioned by Politzer ("Diseases of the Ear," translated by J. P. Cassells, Henry C. Lea & Son, Philadelphia, 1883, p. 649). Cylindroma or myxoma cartilagineum of the cartilaginous meatus has been observed (Meckel, von Hemsbach, cited by Schwartze). Pedunculated warts with normal cutaneous covering, are sometimes seen on the superior wall of the meatus (Von Tröltsch, Politzer, loc. cit.). Sarcoma may develop from the tympanum after an attack of acute purulent inflammation, and may recur in the form of polypoid growths (Hartmann, *Z. f. O.*, viii.); it may also develop primarily from the periosteum of the auditory canal (described by A. H. Buck, in "Diagnosis and Treatment of the Ear," p. 121, William Wood & Co.).

Epithelioma of the ear may originate in the auricle or tympanic cavity and extend to the meatus and surrounding parts. Occasionally, it starts in the meatus with the symptoms of moist eczema (Politzer), or as a rough wart (Kessel, *A. f. O.*, iv., p. 184), or with the formation of a circumscribed crust, which is frequently scratched on account of the great itching, till ultimately the surface becomes ulcerated, the ulcer growing outward toward the auricle and downward toward the membrane. Sometimes the appearance of the growth is preceded by severe pulsating pains and a limited loosening of the wall of the meatus, where, after some weeks, an ulcerated, red-spotted and secreting surface with jagged edges is formed. Besides the spongy growths, there are depressed places on which the white cartilage of the ear and the osseous wall of the meatus are laid bare (Politzer, loc. cit.). The prognosis of epithelioma in the meatus is extremely unfavorable on account of the impossibility of complete extirpation.

Injuries of the Meatus, either from the accidental penetration of sharp substances, or from ill-directed efforts to extract foreign bodies, are quite common. They may set up traumatic inflammation, but are not usually followed by serious results, unless the membrana tympani and parts beyond are involved. Forcible blows upon the lower jaw may cause fracture of the anterior wall of the meatus and glenoid cavity; injury of the deeper parts seldom occurs in these cases. Fractures of the base of the skull not uncommonly extend into the osseous meatus.

Contusion of the head sometimes causes limited fracture, through the thin upper wall of the meatus. Injury of the brain and escape of brain substance through the ear, terminating in recovery, may occur in this class of cases. An instance of this kind was recently seen by the writer. Two years after the injury, the patient was in the enjoyment of excellent health, but in addition to total deafness, with perforation in the anterior superior quadrant of the membrana tympani, there was paralysis of the seventh and atrophy of the optic nerve on the same side.

Scalds and Burns from steam, hot water, and molten metals or mineral acids have been known to occasion more or less destructive and sometimes fatal inflammation.

Frank Buller.

AUDITORY CANAL, FOREIGN BODIES IN. Although the position of the ear is not such as to favor the entrance of foreign bodies into the external auditory canal, it not unfrequently happens that they find lodgment there. Children are much given to thrusting into their ears such bodies as glass beads, pebbles, coffee-grains, and the like; while insects occasionally enter the ear by accident, and sometimes by design, being attracted, perhaps, by the odor of an offensive discharge. Flies, attracted in this way, now and then deposit their eggs in the ear; and unless the discharge be sufficiently profuse to wash them out, they quickly develop into maggots, which soon make their presence known by the great irritation they create. Foreign substances are sometimes put into the ear with criminal intent; but, popular belief to the contrary, the auditory canal furnishes a most indifferent avenue for the introduction of poisons into the system, since its dermal lining does not permit of their ready absorption.

The presence of a foreign body in the ear does not necessarily give rise to serious consequences. If the substance introduced possess irritant or caustic properties, inflammation will quickly supervene, the drum-head may be destroyed, and not only the integrity of the hearing, but life itself, may be jeopardized. And, also, when living insects invade the ear, they usually cause—especially when their wings or claws come in contact with the tympanal membrane—great suffering, and a considerable amount of inflammation of the cutaneous lining of the meatus. But, on the other hand, such innocuous bodies as beads, cherry-stones, coffee-beans, etc., unless they be tightly wedged in the canal, or be so placed as to press rudely upon the drum-head, may scarcely make their presence felt, or induce even a transient earache.

The prevalent belief is that the entrance of a foreign body into the auditory canal is a serious accident, and that, however harmless in itself the foreign substance may be, dire consequences will ensue unless it be quickly gotten out. As a rule, it is doubtless judicious to remove without unnecessary delay any body which has found its way into the external ear, because its presence *may* excite inflammation, or, as sometimes happens, troublesome reflex irritation,* and because, moreover, we shall scarcely be able, without doing so, to allay the alarm of the patient or the anxiety of his friends. But, on the other hand, as in most instances no immediate ill consequences need be apprehended, we should not be too eager to undertake this oftentimes delicate operation, imperfectly equipped, perhaps, for its performance, and under conditions which render doubtful its successful completion; for, if the operation fail of its purpose, the injury resulting from the repeated efforts to extract the foreign body will probably leave the auditory canal inflamed and swollen, and the ear in much worse condition than before. The difficult cases which the specialist has to deal with are, indeed, almost always those in which, through previous unskilful manipulation, the delicate walls of the meatus have been lacerated and bruised, and the foreign body tightly impacted in the bottom of the canal.

Before attempting to remove a foreign body from the ear, the operator should first, by careful inspection, assure himself that one is present. This it is not always possible to do without the aid of an ear-mirror and speculum. If these be not at command, and there be doubt as to the presence of a foreign body (for it is to be borne in mind that patients frequently imagine that something has entered the ear when such is not the case), it is permissible to attempt to solve the doubt by the use of warm water and the syringe; but to grope blindly in the ear, under such circumstances, with any sort of instrument, is a practice fraught with great danger and utterly unjustifiable. It may be well to mention that the glistening surface of the tympanal membrane is sometimes mistaken for a foreign body by those unaccustomed to examining the ear; and as such a mistake is apt to lead to serious consequences, the possibility of it should be borne in mind in order that it may be avoided.

The question of how to deal with a foreign body lodged in the ear depends upon a variety of circumstances: In the first place, upon the nature of the intruding body, whether it be an animate or an inanimate object; and if the latter, whether it be an irritant or an innocuous substance, and what its shape and size. In the second place, upon the manner of its lodgment, whether it be tightly wedged or lying loose in the canal, and whether resting near its orifice or beyond its constricted middle third, in the neighborhood of the tympanal membrane. In the third place, upon the skill and experience of the operator; for what would be a judicious and safe method of procedure for one accustomed to operating

* Among the reflex phenomena which have been observed in consequence of the irritation produced by the presence of a foreign body in the ear may be mentioned, cough, vomiting, excessive salivary secretion, hemicrania, facial paralysis, and epileptic convulsions (Poulet).

upon the ear, might be an extremely unwise and hazardous one for a tyro in this department of surgery to undertake. Generally speaking, it may be said that unless the foreign body be near the external orifice of the ear, and be of such a nature that it may be readily grasped by suitable forceps, in the absence of special skill upon the part of the operator, the syringe is the safest and best instrument with which to undertake its removal. In most cases this plan will prove successful, and when it does not, at least no harm will have been done by the attempt. If it cannot be removed in this way, resort must be had to the forceps, or to the blunt hook devised for this purpose. Neither of these instruments, however, can be used with safety, or to good purpose, unless the meatus be illuminated, so that the foreign body may be kept in view and every movement of the instrument watched. If the intruding body be lying near the external orifice of the canal, it is possible to obtain a satisfactory illumination by turning the ear toward a window or a bright artificial light; but if it be lodged near its inner extremity, a concave ear-mirror attached to a head-band, by means of which either diffuse sunlight or artificial light may be concentrated and reflected into the ear, and in most instances an aural speculum, must be employed. Unless the operator be accustomed, however, to this method of examining the ear, he will not find that he can accomplish much in this way; and, under such circumstances, supposing that the syringe has been used without avail, he will serve his own interest and his patient's welfare, if without more ado he refer the case (if it be in his power to do so) to some one having more skill in this particular direction than himself; for, farther instrumental effort upon his part is little likely to be successful, and may result in serious damage to the ear.


Fig. 355.

In skilful hands a hook, such as the one employed by Dr. A. H. Buck, and represented in the woodcut, is the most generally useful instrument for the extraction of foreign bodies from the ear.* It is especially useful when the foreign body is sphercidal in shape, or is so large as to be wedged tightly in the canal. Under such circumstances forceps are worse than useless; for it is almost impossible to open them wide enough to grasp the foreign body, and each unsuccessful attempt to catch hold of it tends to force it more deeply into the meatus. With the hook, however, which can be gently insinuated between the foreign body and the walls of the canal, and, when it has been gotten beyond it, can be turned so as to catch the body, and, upon its withdrawal, either roll or drag it toward the external orifice of the meatus, any body which has found its way into the ear may be extracted—unless, indeed, it has become greatly enlarged (as sometimes happens from the imbibition of moisture), or the calibre of the canal has been considerably lessened by inflammatory swelling. When such an instrument is not at command, a silver probe suitably bent near its extremity may be used in its stead, or a most excellent substitute for it may be fashioned out of an English steel hair-pin, by separating the prongs until they form with each other an obtuse or right angle, as may be preferred, bending one into a loop for a handle, and then, after filing the extremity of the other prong somewhat flat, bending it over very close to the end and serrating with a file or knife its under surface, that it may more readily catch hold of the foreign body. With such a contrivance the writer has extracted many foreign bodies from the ear. Indeed, it has become quite a favorite instrument with him, and several of them, their extremities differently shaped, form an indispensable part of his armamentarium.

When a corrosive substance finds its way into the ear, it should be syringed out as quickly as possible with tepid water, without loss of time in searching for something which may neutralize it chemically. If such an agent be at hand—as for instance a weak acid, such as vinegar, in the case of an alkaline caustic, or carbonate of soda or potassa, if the corrosive substance be acid, it should be added to the water with which the ear is syringed.

When animate objects invade the ear they usually cause much suffering. Insects, by the rapid movements of their wings and feet, not only excite severe pain, but create an uproar which renders nearly frantic the unfortunate individual into whose ear they have penetrated. Their movements may be arrested, and their lives presently put an end to, by pouring into the meatus any bland oil, such as olive or almond oil, or melted lard when these are not obtainable. Their bodies may then be removed by means of the syringe or forceps. The writer met with a case not long since, in which a physician, possessed of some originality, succeeded in arresting very promptly the distressing movements of a small insect which had entered the ear, by pouring into the meatus a quantity of melted cerate. Unfortunately, however, upon parting with its heat the cerate became hard, and moulded itself firmly into the canal. The remedy, as may be imagined, was worse than the disease, for the discomfort it caused was almost as great, and the difficulty of getting rid of it ten times greater.

Maggots are not only difficult to remove from the ear, but cause very great suffering, because, as Blake has pointed out, they attach themselves, by an apparatus provided for the purpose, to the walls of the meatus, and feed upon the inflamed integument. It is frequently necessary to seize and extract them with forceps, as the syringe will not always bring them out.* They survive for some time in oil, live only five or ten minutes in alcohol, and are killed instantaneously by chloroform (Burnett). Alcohol, however, is not a desirable thing to pour into an inflamed and excoriated meatus, and to use chloroform in this way is, of course, out of the question. Dr. Roosa recommends chloroform vapor and also Labarraque's solution of chlorinated soda to destroy them with, when it becomes necessary to do this before removing them from the ear.

To relieve the pain and inflammation caused by a foreign body in the ear, or by the efforts to remove it, the writer has found nothing so useful as the French anodyne oil, known as *oleum compositum* or *baume tranquille*,† of which eight or ten drops may be warmed and dropped into the ear three or four times a day. Probably, for this purpose the newly discovered local anæsthetic, muriate of cocaine, will be found to act efficiently. The anæsthetic action of this salt may also be availed of to facilitate the removal of foreign bodies from the ear, by lessening the sensibility of the walls of the meatus. Its effect, however, will not be so striking here as it is upon the eye; although, if the writer's, at present, limited experience in this direction is to be relied upon, it will prove of real value. With nervous children, however, it will still be necessary in many cases, as heretofore, to administer a general anæsthetic, not so much to lessen the pain of the operation (which in uncomplicated cases should not be considerable), but to overcome the fear and quiet the resistance of the patient.

The operation of displacement of the auricle and cartilaginous meatus to facilitate the removal of foreign bodies from the ear, which has been practised occasionally in Europe and in this country, does not commend itself to the judgment of the writer as a justifiable or

* Dr. Buck's hook is about fifteen centimetres in length, and is straight. The writer employs a hook which differs from Dr. Buck's chiefly in that the shank, which is six and a half centimetres in length, forms an angle of about 100° with the handle. The hook at the extremity of the shank is also not quite so long as the one represented in the cut, and bends over less abruptly. It is serrated, too, upon its under surface. In his opinion the angular form is preferable, as with it the operator's hands are less likely to interfere with the illumination of the meatus, than when a straight instrument is employed.

* The writer once removed from the ear of a woman a live tick, which had been there for about a fortnight. It was firmly attached to the wall of the meatus, and when it was seized with forceps considerable traction was required to break its hold. A black granular material (its excrement) had been coming from the ear for some days, at times a sound "like broiling" had been heard in it, and pain was beginning to be experienced.

† For formula see French Codex, p. 308, and p. 1581 of the U. S. Dispensatory, 15th edition, 1883.

useful procedure, and he can scarcely conceive of a case which would warrant recourse to such an expedient. *Samuel Theobald.*

AUDITORY NERVE, DISEASES OF. The chief characteristic of disease of the auditory nerve and its terminal portions in the labyrinth—and in the latter the cochlea is to be included, whenever that term is used in this article—is deafness more or less profound and sudden in its onset. The best test of the extent of deafness from disease of the auditory nerve is speech, as it is for all forms of deafness. But unless both ears are simultaneously affected by disease of the auditory nerve, it is difficult to isolate the good, or better ear, from the affected one in this mode of testing the hearing. Hence, as a better means of isolation of one ear from the other in testing, the aurist has recourse to the tuning-fork. For, if a vibrating tuning-fork of deep note be placed either upon the vertex or in the meatus of an acutely affected ear, and be unheard by the latter, it may be assumed that the lesion is in the labyrinth, *i.e.*, that there exists a disease of the auditory nerve-structures. In chronic deafness, however, it must be remembered that invisible changes, like anchylosis of the stapes in the oval window, or exostoses in or about the fenestræ, upon either the tympanic or labyrinthine surfaces, may have taken place, and, having caused or aided in the profound deafness, cannot be entirely excluded in this form of testing. It is even held by some observers (Lucæ: *Archiv f. Ohrenh.*, Bd. xviii., p. 189) that bone-conduction, *per ossa capitis*, the handle of the vibrating tuning-fork being upon the vertex, is an unreliable means of diagnosing diseases of the labyrinth, on account of the co-vibrations in the sound-conducting parts of the ear. It is therefore maintained by many aurists that the demonstration that certain musical notes, conveyed to the ear by aërial conduction, are not heard, is of far greater diagnostic value, since such deafness, even for some notes, is ascribable only to an affection of the auditory nerve in some of its parts in the labyrinth, and most probably to one limited to the cochlea. It must be borne in mind that disease in parts of the internal ear is not attended by total deafness, whereas a disease in the trunk or central portions of the auditory nerve would be attended by the profounder forms of deafness, and, in some instances, by other cerebral symptoms. Lucæ claims that "Rinne's method of testing is important in making a diagnosis of disease in the internal ear. Thus, if the sound of a tuning-fork, after it is no longer heard on the mastoid, be perceived when held before the ear, a disease in the sound-conductors can be excluded; whereas a longer perception from the mastoid than before the ear indicates the absence of disease of the inner ear." The great obstacle, however, in diagnosing disease of the ear by means of the tuning-fork, *per ossa*, is that the statements of the patients cannot be depended upon, as they are unable to discriminate properly between what they hear by the air and that heard by bone-conduction, and also between hearing and feeling. This unfortunate fact impairs greatly the value of the tuning-fork in diagnosis. Nevertheless, coupled with vocal tests, and those by musical instruments by aërial conduction, the tuning-fork is at least a valuable accessory aid in diagnosing disease in the auditory nerve and internal ear.

Nervous Deafness.—It is held by some authorities (P. McBride: *Lancet*, 1881) that pathologico-anatomical causes cannot be adduced as explanatory of every case of deafness. In such cases a functional disturbance in the auditory nerve is held to be the cause of the alteration in hearing. As, for example, the diminished hearing, occurring in catarrhal subjects upon entering a warm apartment from the cold, open air, or the decided diminution of hearing which ensues in those affected by catarrhal disease of the ear, by an attack of dyspepsia or any similar intercurrent cause of nervous depression. Malaria may be cited as among the latter.

It is highly probable, however, that alterations in hearing, generally classed as instances of nervous deafness, are in many instances not affections of the auditory nerve. Such forms of hardness of hearing are more likely to be due to reflex changes in the vascularity of the Eustachian tube and middle ear, induced by the effect of the depressing cause, like dyspepsia, malaria, hysteria, venery, etc., upon the trophic and vaso-motor nerves of these parts. Functional changes in the auditory nerve are not distinctly definable. Central deafness has been described by Bürkner (*Archiv für Ohrenh.*, Bd. xxi., p. 177). It appears, from the history of a case reported by him, that a merchant forty-seven years old, who possessed perfect hearing and vision, received distressing and very unexpected news when travelling, and hastened home. In three or four days he became hard of hearing, and in the course of two months entirely deaf; in six months he became blind. The affection was declared to be a nervous one. Vertigo and disturbed equilibrium were also noted. At first most distressing subjective noises were perceived, but finally they subsided. The objective examination of the ear gave negative results. The simultaneous occurrence of deafness and blindness, the failure of every trace of bone-conduction, the absence of all objective symptoms on the part of both organs of sense, were held by him to render the diagnosis of a central lesion extremely probable; but its precise nature was not definable. Syphilis was not held accountable for the symptoms.

Paralysis of the sympathetic nerve in the neck is said to be characterized by a sudden loss of sight and hearing, with very violent pains, on the corresponding side of the head. Considerable narrowing of the pupil and retinal vessel-dilatation may be detected, but no abnormality is seen in the ear. The diagnosis of paralysis of the sympathetic, with consecutive dilatation of vessels on the right side of the head, has been verified by the treatment, since all manifestations disappeared after four days' treatment with ergot of rye (Kispert: *Deutsche Zeitschrift f. prak. Med.*, 1878, and *Arch. f. Ohrenh.*, Bd. viii., p. 197).

Central Affections of the Acoustic Nerve.—The phenomena of transference of aural phenomena may occur in hysterical cases, affected with pain in the back and in the intercostal region, aphonia, and in some instances with paresis of the arm on one side, and deafness on the other (Urbantschitsch: *Archiv f. Ohrenh.*, Bd. xvi., 3). Upon placing a small horseshoe magnet directly upon the left mastoid (the deaf side), and bringing it within some millimetres of the hyperæsthetic right mastoid, complete deafness followed in the right side, in from five to eight minutes, and the left ear became as good as the right ear had been. This had not been perfect. The same transference occurred in the blind left eye and in the anæsthetic skin.

Although not strictly pertaining to disease of the auditory nerve, the *hysterical element in disease of the ear*, as well as aural symptoms occurring sometimes in hysteria, should be mentioned as nervous phenomena connected with the ear. C. J. Blake and G. L Walton, of Boston, have recently reported two cases (*Annales des Maladies de l'Oreille et du Larynx*, September, 1884), one illustrating the extent to which an aural disease, severe in its objective as well as its subjective symptoms, may be simulated in an hysterical patient, and the other showing the influence which an existing aural disease, of comparatively mild character, may have in originating marked hysterical symptoms in a case already endowed with an hysterical tendency, and, reflexively, in exciting symptoms leading to the apprehension of aural disease much graver than in reality exists.

Affections of Hearing and Speech, from Disease of the Temporal, Occipital, and Lower Parietal Lobes of the Brain.—Ferrier and Munk proved that a destruction of the temporal lobe caused abolition of the reaction to sound. Ferrier maintained that the cortical seat of the function of hearing lies in the temporal lobe. There is cited the case of a woman, forty-two years of age, who lost her voice and hearing after suffering from intense headache for three months. At the post-mortem examination, a colloid degeneration of the temporal lobes of both sides was found, more marked upon the left side than on the right. The posterior half of the third frontal convolution was also af-

fected. In a second case there had been hemiplegia which had disappeared. There were still symptoms of ataxic aphasia, of a subparalytic condition of the tongue, and of an inability to distinguish words, though the hearing was said to have been normal. A post-mortem examination revealed pachymeningitis hæmorrhagica, by which the left temporal lobe as well as the third frontal convolution had been compressed, and degeneration induced. The difficulty in speech was caused by the disease in the third frontal convolution. The sensory aphasia, or inability to distinguish words, is attributable to disease of the temporal lobe (Kohler und Pick: 1870; see Review, *Archives of Otol.*, vol. ix.).

The same observers demonstrated, by several examples, how ataxic aphasia and deafness for words can be distinguished by their clinical features. As is well known, the principal difference between the two is, that in aphasia both the hearing and understanding of spoken words are present, while in sensory aphasia hearing is preserved, but an inability to understand words exists (*Zeitschr. für Heilkunde*, vol. i., H. 1).

In a case of aphasia, paraphasia, and deafness for words, J. Fritsch, of Vienna, found softening of the lower parietal lobe, of the adjoining posterior portion of the first and second temporal gyri, of the posterior transverse temporal gyrus, and of the posterior gyrus of the island of Reil. A portion of the second occipital gyrus of the occipital lobe, a few millimetres in breadth, was similarly affected. Embolism of the parieto-sphenoidal branch of the left artery of the Sylvian fossa was found (*Wiener Med. Presse*, No. 15, 1880; also *Archives of Otol.*, vol. ix.).

Atrophy of the occipital lobe is found in some cases of profound deafness of long duration. In a case of deafness which had existed for sixty years, the left occipital lobe was atrophied and of irregular surface, the central furrow was deepened enough to receive the index-finger, and the groove between the *lobulus tuberis* and the posterior central convolution was also deepened. The third frontal convolution was atrophic; the right occipital lobe also showed atrophy of its cortical substance, and the sulci were deepened. The trunks of the auditory nerves had disappeared, with the exception of a few fibres. Also in a deaf-mute, seventy-four years old, atrophy of the occipital lobe was found (Luys: *Gazette Méd.*, No. 29, 1880; *Archives of Otol.*, vol. x., 1881, p. 80).

Lesions of the temporal lobe produce alterations in hearing, as in a case described by Wernicke and Friedländer (*Fortschritte der Medicin*, No. 6, 1883, and *Archiv für Ohrenh.*, xx., 149). The patient, a woman, forty-three years old, had been an epileptic for eighteen years. Finally, the epilepsy, headache, nausea, and retching became more distressing, and the muscular power in the left hand became defective. In the course of eight months, the epileptic attacks were regularly attended by twitchings of the left arm, and then occurred a simultaneous diabetes insipidus and considerable hardness of hearing, from which the patient had been previously free. The eyesight was undisturbed. In the course of two or three months she was attacked by apoplexy, followed by aphasia and right hemiplegia. When consciousness returned, she uttered unintelligible sounds. In two months, though she could speak, she could not make herself understood, and she remained paretic in the right arm. In another month the left arm became paretic, the right arm having become entirely well. The confused and unintelligible speech remained, and the patient had become entirely deaf. With symptoms of profound leukæmia and hæmatemesis, the patient died a month later. Post-mortem examination, the day after death, revealed syphilis, gummatous softening of both temporal lobes, proctitis ulcerosa, with perforation of the vagina, gummata in the liver, marked tumefaction of the spleen, leukæmia, and hæmorrhages into the stomach and alimentary canal. The dura mater was moderately tense and adherent to the pia mater and the brain, over both temporal lobes, and upon the right side it was adherent to the contiguous parts of the lower part of the parietal lobe, for a space the size of a German mark-piece. The brain substance was soft at these points, partly white and partly brownish, and consisted of large-celled granulation-tissue, with homogeneous, slightly fibrillar, intercellular substance, whereas the normal elements of the cortex, especially the ganglion-cells, were absent; otherwise the brain was normal. It was found that the new growth comprised all of the first and second convolutions, a portion of the neighboring convolution, and some of the temporal lobe. Forward, there was a narrow extension of the growth, limited to the first and second convolutions, as far as the border of the front and middle third; posteriorly it extended into the substance of the second convolution to within half an inch of the lower occipital groove. On the right side, only the upper and posterior part of the temporal lobe was attacked; the most important change was found in the under parietal lobe, and extended beyond the anterior occipital groove, into the beginning of the occipital lobe.

The deafness was developed during the course of the brain-disease and increased with it, so that the ambilateral lesion of the temporal lobe is to be considered the cause of the deafness. No disease was found in the middle or external ear to account for the deafness. Since, furthermore, there was no increase in the cranial pressure from within, as there usually occurs with tumors of the posterior cranial fossa and in hydrocephalus internus, which explains the deafness, there remain simply the centres of disease in the temporal lobes to explain the deafness in this case.

In intimate relation with the deafness stands the no less important destruction of the power of speech in the patient. This was not due to that evanescent destruction of speech accompanying the apoplexy, which may be considered as a concomitant of the simultaneous hemiplegia on the right side, and, according to Wernicke, is best denominated motor aphasia; but it was due rather to the permanent injury of the power of expression which the patient maintained till her death, and which corresponds exactly to that phenomenon observed in a number of cases of destruction of the first left temporal convolution. Wernicke has, from previous observations, drawn the conclusion that the memory of auditory impressions is deposited in the temporal lobe. It has remained a matter of constant verification that the loss of the memory representations also injures the power of speech.

"It must be borne in mind that through the possession of sound-pictures of speech, a continuous, unconscious control of the act of speech occurs, the projection of which is confusing in such cases of disease."

Hallucinations of Hearing in the Insane.—Hallucinations of hearing may be present in those affected by hæmorrhagic pachymeningitis (see Internal Ear and Auditory Nerve in Psychic Derangement). In those who suffer from such aural phenomena during psychic derangement, organic changes may be found after death, consisting in atrophy of the semicircular canals, with fatty deposits in the cellular structures in the labyrinth. These, however, may be partly senile changes (Moos: *Archiv für Ohrenh.*, Bd. xiv., 273). But even in persistent hallucinations of hearing, the entire auditory apparatus may be found normal (Gellé). Such cases have been considered due to changes in the convex surface of both cerebral hemispheres (Luys). But, as in such a case the carotid artery has been found dilated at some points, while indurated and narrowed at others, in its passage through the temporal bone (Gellé: *Tribune Méd.*, 30 Mars, 1879), a tinnitus aurium would certainly exist from the impeded flow and morbid vibrations in these blood-vessels. Such tinnitus occurring in an insane subject would, of course, be misunderstood by the sufferer, and give rise to hallucinations of hearing. Fischer has made a series of investigations in subjects affected with auditory hallucinations. In a case of pronounced melancholia with vivid hallucinations of all the senses, he found that no sensation was excited in the acoustic nerves by strong galvanic currents, and that the hallucinations ceased almost entirely during continuance of the current. A regular galvanic treatment of the brain with eight or ten elements, the current being passed through the head from side to side and from back to front, car-

ried out every day for two months, effected steady improvement, and eventually complete cure. Upon the cessation of the subjective noises in the ear, the hallucinations disappeared. Fischer believes that in such cases delicate disturbances in the nutrition of the central nervous system underlie the auditory affection.

In an aged lunatic who had been afflicted with auditory hallucinations, hyperostosis and exostosis, anchylosis of the head of the hammer, bony occlusion of the round window, and colloid degeneration of the auditory nerve in the petrous bone were found after death (Moos and Steinbrügge: *Archives of Otology*, vol. xi., p. 8, 1882), showing that aural disease productive of tinnitus aurium in ordinary normal psychic conditions, is sufficient to be misinterpreted by the insane into hallucinations.

The Internal Ear and Auditory Nerve in Psychic Derangement.—In atrophy of the brain and hydrocephalus externus, there may be found chronic ostitis of the cranium and of the temporal bone, and chronic periostitis of the tympanic cavity, with partial anchylosis of the ossicles and shortening of the tensor tympani. There may be also senile alterations in the cellular structure of the labyrinth in aged subjects. The degree of deafness is usually great, but one ear may be better than the other, and to the better side the patient may refer hallucination of hearing. The membranous semicircular canals may be found very atrophic on one side, but less so on the other, while on both sides the epithelium on the membranous semicircular canals, as well as in the vestibular structures, and also the cellular tissues of the lamina spiralis membranacea, may show great quantities of fat-globules, as in a case observed by Moos and Steinbrügge (*Archives of Otology*, vol. viii., p. 126). These were regarded as senile changes. The substance of the pillars of Corti's arches may preserve a normal homogeneous appearance in the presence of the above-named changes.

Histological changes in the labyrinth occur in connection with hæmorrhagic pachymeningitis in the insane (*Hæmatoma duræ matris*). Thus in a man, aged forty-seven, affected by this cerebral disorder, the hearing entirely failed in the course of a year. There were, in this time, four paralytic attacks, with marked further decrease in hearing after each stroke. Death occurred in the course of two years. The autopsy revealed the skull vault smooth on both surfaces, but greatly thickened. The dura mater was firmly adherent to it. Upon the inner surface of the dura mater there were pale, gray pseudo-membranes, stratified, not very thick, and free from hæmorrhagic deposits, enclosing about two hundred cubic centimetres of yellowish serum, the transformed elements of the hæmatoma (Moos: *Archives of Otology*, vol. ix., 1880). In another case reported by the same author, aided by Steinbrügge (*Archives of Otology*, vol. x., 1881), an insane woman, aged seventy, ten months before her death developed ptosis of the left eye, with contraction and immobility of the left pupil. There were slight clonic spasms in the tract of the right facial nerve, with normal sensibility. There were complaints of frequent dizziness and loss of bearings. The hearing on the left side seemed better than on the right. The autopsy revealed a large quantity of fluid in the subdural space of the spinal cord, hæmorrhagic pachymeningitis, atrophy of the brain in all its parts, and macroscopic signs of hæmorrhagic discoloration upon the acoustic nerve in the *porus acusticus internus*, on both sides. A similar condition was detected in the transverse part of the left facial canal.

There were microscopic extravasations of blood found between the fasciculi of the vestibular nerves near their exit, and throughout the cochlear nerve up to its entrance into the modiolus. Degenerated blood-corpuscles were found between the primary nerve-fibres in the modiolus in only one instance. The blood-vessels throughout the labyrinth were congested. The cubical and polygonal shape of the blood-disks was held to be an evidence of stagnation. There were no signs of inflammation. In this case the hearing was not so much reduced, and the cerebral changes were less extensive. The structure of the nerve-trunks and their expansions in the cochlea were normal, as were the soft parts in the vestibule, cochlea, lamina basilaris, and organ of Corti; whereas, in the first given case there were cell-infiltrations of the walls, thickening, dilatation, and even obliteration of blood-vessels. When such extensive changes in the labyrinth are found, there have been previously numerous hæmorrhages, followed by increase of deafness after each attack. When only one hæmorrhagic attack takes place, the deafness is slight and curable, as is also the hæmatoma of the dura mater. (See Concussion of Labyrinth.) Moos and Steinbrügge report another case of hæmorrhagic pachymeningitis ending with pyæmia, acute degeneration of both acoustic nerves, and thrombosis of the right internal auditory artery. The hæmorrhagic deposits occurring in these cases may be found on the dura mater covering the posterior surfaces of the temporal bone, and continued into the internal auditory canals. Under the microscope this deposit is seen to be composed of delicate, wavy connective tissue, enclosing endothelial cells from the arachnoid, newly-formed blood-vessels, blood-corpuscles nearly converted into pigment, besides a great quantity of completely formed pigment, the result of previous hæmorrhages. The internal auditory artery may be found thrombic in different places. Beyond the thrombi vessels empty, and are surrounded by extravasation. Nerve-fibres are seen in all stages of degeneration. The degeneration of the auditory nerve is probably caused by a subdural and intrafascicular extravasation of blood. This tears a great number of fibres, and deprives them of nutrition. When only the central part of the nerve is affected, the peripheral and terminal fibres remaining intact, the conclusion may be made that the entire process in the auditory nerve occurred in the last stages of life (Moos: *Archives of Otology*, vol. xi., 1882).

The auditory disturbances in hæmorrhagic pachymeningitis may be due to hæmorrhages by transudation into the labyrinth, which accompany the meningeal hæmorrhages, and which in repeated attacks may lead to total destruction of the function of hearing. The deafness, then, is brought about by atrophic and degenerative processes in the labyrinth, in which both the trunk of the auditory nerve and its terminal expansion are pre-eminently involved, and in the causation of which the disturbances in the circulation and in the nutrition of the tissues, form an important factor (Moos: *Archives of Otol.*, vol. ix., pp. 106 to 144, 1880). The same author has also shown that, in consequence of such hæmorrhagic processes in the labyrinth, there ensues inflammation, which leads partly to hyperplasia of the connective tissue, which finally may undergo fatty degeneration. With this may be found partial atrophy, in the form of degeneration of the epithelial tissue and nerve-elements. The latter may become very atrophic, and display abundant colloid transformation. In the atrophic parts of the nerve there may be numerous molecular fat-globules, which probably emanate from the degenerated myeline. Such atrophy can be followed to the ganglionic cells, and even to the terminal nerve-fibres of the crista of the ampullæ. The alterations in the labyrinth appear to be connected with the intracranial process, from the similarity of the alterations in the vascular tract of the internal auditory artery to those of the meningeal artery, as already described by Kremiansky and Rindfleisch.

Rachitic Alterations and Disturbances in Development in the Ears of Cretins.—Chronic leptomeningitis and hydrocephalus internus, hyperostosis of the cranium, sclerosis of both mastoid portions, and osseous malformations in the middle and internal ears, have been found associated with cretinism by Moos and Steinbrügge (*Archives of Otology*, vol. xi., 1882). Both auditory nerves, in such a case, were similarly affected in the internal auditory canals, viz.: the ganglionic cells were full of pigment, and the nerve-fibres were of a sepia tinge, partly broken up into tænia-like divisions, with regular lines of demarcation, probably representing the nodes of Ranvier. Their axis-cylinders were distinct, but minute. The vessels of the labyrinth were greatly congested, though otherwise the soft tissues in the laby-

rinth appeared normal. The patient, though dumb, could hear a little, probably, as it was thought, by bone-conduction.

Aural Vertigo: Neuropathic Form.—A neuropathic form of aural vertigo (Ménière's disease) may be said to exist in connection with some forms of disease of the auditory nerve. The affection may lie either in the central origin of the nerve, along its trunk, or in the terminal filaments within the labyrinth. It will be in place here to consider simply the train of symptoms of a so-called Ménière's disease, arising from a central disorder of the auditory nerve. These may ensue in an apparently healthy man or woman, as in a case described by O. Wolf (Fifty-second Meeting of German Physicians and Naturalists, 1879). In this instance, in a woman forty-six years old, there suddenly developed violent tinnitus in the left ear. The hearing failed, with marked inability to hear certain series of tones, and there was a confusion of consonants. There were no changes found in the conductive apparatus. For a year, the tinnitus and hearing remained unchanged—unless it might be that the latter grew worse. In the second year, there were frequent attacks of vertigo of greater or less intensity, especially in raising the head; but there was no inclination to fall in any particular direction. The tinnitus could be relieved by the constant electric current. In the course of two and a half years, ptosis and dilatation of the pupil on the left side were noted, together with great pain in the left parietal region. The patient began to move about only with aid, and stepped peculiarly high, like a chicken. Soon after this she was confined to bed, and could raise her head only with assistance. The muscles of the neck in such cases may become tender, but there may not be any contraction. The patella-reflex may remain normal and the cutaneous sensibility unaltered. Four weeks before death, in the case alluded to, facial paralysis on the left side set in; the sensorium remained clear most of the time, though there were periods of maniacal excitement with delusions. The left ear remained deaf, the tinnitus became less, but the parietal headache was intense. There was constipation, and the urine was either voided involuntarily, or it had to be drawn by the catheter. Finally, speech became difficult, slow, and rattling, and death occurred from paralysis of the palate with pneumonic symptoms.

The post-mortem examination revealed a normal condition of the cranial bones. In the tonsilla cerebelli on the right side, there was found a tumor the size of a large cherry, reddish in color and firm in consistence, vascular, and with uneven surface, which pressed upon the origin of the acoustic nerve in the fourth ventricle, in such a manner as to obliterate the striæ acusticæ on that side, and to produce paralysis of the left auditory nerve. Furthermore, the meninges at the base of the brain were inflamed. A second but smaller tumor, the size of a small hazel-nut, was found in the cortical portion of the cerebrum on the right side, near the sulcus in the central gyrus. The brain was soft in the vicinity of the tumors, and to the presence of this latter one were attributed the headache and attacks of mania. The genesis of the tumor was explained by the occurrence of numerous foci of endo-arteritis in the basilar artery. The microscope revealed in these tumors a rich growth of so-called granulation-cells, numerous vessels, and in many places connective tissue-fibres, and they were diagnosed as gummata. It was known that twenty years previous, the patient had had syphilis, had undergone inunctions for it, and was supposed to have been cured. Certainly, she had manifested no signs of it since, and her children were entirely healthy.

Alterations in the cerebellum, near the origin of the acoustic nerve, begin with tinnitus and alteration, or even abrogation, of the sense of equilibrium, and hence they may be confounded with labyrinthine disease. But permanent alteration in gait and in the sense of equilibrium, and perhaps implication of other nervous tracts, sooner or later show the central nature of the nervous change.

Changes in the Auditory Nerve and Internal Ear, Due to Chronic Otorrhœa and Caries.—In consequence of chronic purulent aural disease, attended with marked changes in the middle ear, great alterations may ensue in the internal ear, as shown by McBride and Bruce (*Archives of Otology*, vol. ix., p. 365, 1880). The vestibule may be filled by a white mass composed of pus-cells and fat. The cochlea may be entirely destroyed, and the osseous tissue near the semicircular canals permeated with rod-like bacteria. These may be found between the lamellæ, and also in the perivascular lymph-spaces, in the adventitia of the arteries, and within the bony semicircular canals, as well as between the fibres of the facial nerve. The veins may contain plugs composed of bacteria. These observers are inclined to draw the conclusion that cerebral abscess from ear-disease is due to migration of micro-organisms from the ear, either through the blood-vessels or by the way of the connective tissue about the vessels.

In a case of fatal ear-disease these same observers (*Journal of Anatomy and Physiology*, xiv., p. 360) found, as a result of the invasion of the internal ear by chronic purulent otitis media, purulent matter in the vestibule, and entire destruction of the terminal apparatus in Corti's organ. The bone about the labyrinth was infiltrated with bacteria, especially copious in the perivascular spaces. This infiltration was also found in the smaller vessels and in the trunk of the auditory nerve. In the right half of the cerebellum there was an abscess the size of a walnut, in the pus of which were numerous bacteria. The cerebellum at this point was adherent to the dura mater of the diseased petrous bone.

In a case of chronic purulent otitis media, terminating after eighteen years duration in paralysis of the facial nerve, total deafness, and abscess of the cerebellum, besides extensive destruction of the parts in the middle ear and of the bone about the internal ear, in the pyramidal part of the petrous bone, great microscopic changes were discovered in the internal ear by Moos and Steinbrügge (*Archives of Otology*, vol. x., and *Archiv für Ohrenh.*, Bd. xvii., pp. 287, 288, 1881). There had ensued numerous carious destructions in the modiolus and cochlear capsule. Such destructions, however, were few near the vestibule and semicircular canals. The nervous elements in these districts were nearly entirely destroyed. The fibres of the acusticus were found in all stages of atrophy, with marked increase, *i.e.*, hyperplasia of its connective tissue. The transverse portion of the facial nerve, running inward from the hiatus, appeared as a thin, gray, gelatinous, and very brittle string, the result of granular degeneration of its axis-cylinder. Its horizontal portion, from the hiatus to the foramen ovale, and also the petrosus superficialis major nerve, had become enlarged on account of a thickening of their neurilemma. The fibres of the facial nerve, inward from the centre of softening, were broadened by a swelling of their marrow-substance, nodulated, and twisted, but they maintained their double outline, and manifested only a very slight degree of granular degeneration.

The entire lamina spiralis membranacea was wanting. In its place there was detritus colored brown by osmic acid, in which were portions of the zona pectinata. The same kind of detritus was found filling the vestibule; the sacculi were destroyed. The region of the crista in one of the ampullæ was infiltrated with dark granules. At this point there was evidence of great degeneration of nerve-elements, the fibres having lost their double outline, and exhibiting sparse and very small axis-cylinders.

Permanent Alterations in Hearing Produced by the Use of Quinine and Salicylic Acid.—*Clinical Features.*—After large doses of quinine have been administered, well-known aural symptoms, such as tinnitus and roaring sounds in the ears, with constriction in the head and deafness, set in, which vary in intensity and duration according to the dose given. It has been supposed by many that the permanent deafness which often ensues after quinine has been taken in large doses is due to the febrile disease for which this drug has been administered, and the same has been claimed for the hardness of hearing which follows salicylic acid. But the latter drug is comparatively new, and not having

been employed so frequently as quinine, has not been so often considered the cause of permanent deafness. There is reason to believe, as will be shown hereafter, that permanent alterations in hearing may be produced by large doses of quinine. If to a strong man, perfectly healthy, without previous aural disease, and without any syphilitic taint, a dose of a quinine salt, like the sulphate or the muriate, be given in quantities varying from one to eight grammes, there will be observed within a few hours marked dulness of hearing, intense roaring tinnitus in the head and ears, and a sensation of constriction in the head, while in some cases vertigo and pain in one or both ears will be experienced. The watch may be heard only in contact, having been previously well heard, and bone-conduction seems abrogated as it is in syphilitic deafness, due to disease of the internal ear. The membrana tympani, in such cases of quinine deafness, seems to undergo a speedy change in appearance, assuming a hazy look, as observed by Kirchner, Schilling, Schwabach (*Deutsche med. Wochenschrift*, No. 11, 1884), and others. This is due to the congestion and intense hyperæmia of the mucous surface of the drum-membrane, which is so well known to occur after large doses of quinine.

The participation of the labyrinth is shown clinically by the inability of the patient to hear a watch tick and the tuning-fork through the bones of the skull, and also by inability to hear high notes by aërial conduction, either very imperfectly, or not at all. The inability to hear high notes is due to the congestion which ensues at the lower whorl of the cochlea, where the nerve-fibres of hearing for high notes are supposed to lie. As this is near the promontory and the latter nearest the vessels of the drum-cavity, and as an intimate vascular anastomosis exists between the labyrinth and middle ear (Politzer), it is readily seen how the tympanic congestion, so easily induced by quinine, can be communicated to the labyrinth and cochlea.

Salicylate of soda and salicylic acid do not seem to affect the ear as quickly nor so extensively as quinine. There is no doubt, however, that large doses of salicylate of soda, *i.e.*, 1.0 gramme every hour for five hours (Schwabach, *loc. cit.*), will induce tinnitus aurium and deafness, or make these symptoms worse if they already exist, and perhaps aid in the production of permanent changes in the labyrinth, as asserted by Kirchner. If after two or three doses of salicylate of soda, *e.g.*, one gramme every two hours, have been taken, tinnitus aurium and deafness ensue, cessation of the dosing will be followed by disappearance of the aural symptoms; but if these doses are resumed, the auditory discomfort is rapidly reproduced. The hearing does not seem, however, to be permanently altered by the administration of salicylate of soda, although the tinnitus it produces may remain for a long time.

It is claimed by Schwabach that even small doses of quinine or salicylic acid may produce permanent deafness.

In such cases, there may be an idiosyncrasy rendering the subject especially liable to be affected by these drugs, just as in some individuals the skin is readily affected by certain drugs, as shown by the speedy eruption on the cutaneous surface following their administration. The peculiar effects of quinine and salicylic acid, upon the auditory apparatus, are presumably due to the vessel-dilating power which they possess. To overcome this effect, it is recommended (Schilling: *Münchener ärztl. Intelligenzblatt*, No. 3, 1883) that the vessel-contracting drug, ergot, be given shortly after the dose of these drugs is administered. This observer states that in eighty-seven cases he combined salicylate of soda with ergot, and found that in seventy-six per cent. of the cases no effect of this drug upon the organ of hearing was detected. In nine cases in which he combined ergot with quinine, one gramme to one and a half gramme of fresh secale cornutum or one gramme of ergotin, these cases had either no aural symptoms or very slight ones, while in those cases in which the quinine alone was used, the aural symptoms were intense.

The antirheumatic and antifebrile effects, respectively, of these drugs are not impaired by such a combination of the controlling drug. In this connection it will be well to recall the suggestion of Finkler and Prior (*Deutsche med. Wochenschr.*, No. 6, 1884), that amorphous borate of quinine is an efficient antipyretic and antiperiodic remedy, and possesses besides the great advantage of not inducing tinnitus aurium to the same extent as the muriate of quinine. One of these observers took 0.5 gramme of this drug without any auditory distress, whereas the same quantity of the muriate of quinine induced headache and tinnitus aurium so intense as to keep him awake all night. Without doubt, an intolerance of the salts of quinine most in use exists in some, while it is absent in other subjects. This should be borne in mind by the clinician, and when he resorts to their use in large doses at a time, a controlling drug should be employed, both in order to give comfort to the patient and to save his internal, or his middle ear, or both, from permanent injury. The histological changes induced by large doses of quinine are demonstrated by the experiments of Kirchner, soon to be described.

Hyperæmia of, and Hæmorrhage into, the Labyrinth.—Hyperæmia and hæmorrhages may ensue in the labyrinth from large, poisonous doses of quinine and salicylic acid (W. Kirchner: *Archiv für Ohrenheilkunde*, Bd. xviii., p. 305; and *ibid.*, Bd. xx., p. 209). Besides hyperæmia, the same observer has detected extravasations in the cochlea and semicircular canals from the same causes. Thus in a cat, to which large doses of quinine had been given, a copious extravasation, consisting of white and red blood-corpuscles, extended from the *vas spirale*, over parts of the *sulcus spiralis*, the *vas spirale*, the auditory pillars, Corti's arches, and the *membrana basilaris*. In a preparation taken from a rabbit, an extravasation could be seen extending from the semicircular canals to a vessel of the surrounding osseous substance. In a woman, who had taken for a long time large doses of salicylic acid, Kirchner found, after the subsidence of the labyrinthine symptoms (*i.e.*, vertigo, roaring noises, and constriction in the head, with reeling), an exudation in the tympanic cavity, which necessitated *paracentesis membranæ tympani*.

In cases of acute quinine deafness it may be assumed, therefore, that paralysis in the walls of the vessels and exudations ensue in various parts of the auditory apparatus. It is well known that the fundus of the auditory canal, and the membrana flaccida, and lower portions of the membrana tympani are congested by large doses of quinine. These cases are those in which the tympanic cavity is congested, and probably those instances of quinine deafness which recover. When, however, after large and long-continued doses of quinine, the hearing is greatly and permanently impaired, it may be assumed that the hyperæmia, hæmorrhage, or extravasation, which has ensued in the labyrinth, has inflicted irreparable injury upon the percipient parts of the organ of hearing.

Hyperæmia of the head, with simultaneous injection of the membrana tympani and pulsating tinnitus, if accompanied by impairment of hearing, lead irresistibly to the conclusion of hyperæmia of the labyrinth. Hæmorrhages into the labyrinth may occur not only from fractures of the base of the skull and petrous bone, but also from simple concussion; also in typhoid fever, acute tuberculosis, and in other diseases (Lucæ: *Eulenburg's Real Encyclopädie*, viii., 1881; also *Arch. f. Ohrenh.*, Bd. 18, p. 188). Anæmia seems to produce alterations in the hearing, but it is not possible to give any pathological explanation of this phenomenon from post-mortem data. It seems highly probable that in some cases of concussion of the labyrinth hæmorrhagic effusions occur, which are followed by deafness and other symptoms of labyrinth commotion. From the recovery of the hearing and the disappearance of the other symptoms of disturbance in the labyrinth, in the meanwhile there having been no symptoms in the external or middle ear to account for the aural phenomena present, the diagnostician is forced to conclude that the effusion in the labyrinth has not been

great, and has been absorbed, before permanent impairment of function in the nerve-structures of the inner ear has ensued.

HÆMORRHAGIC INFLAMMATION OF THE COCHLEA.—In some cases of deafness, so great that words are heard only when spoken directly into the ear, and in which the notes of a melodeon are heard from *c'* downward better than the higher ones, a post-mortem examination may reveal, besides chronic catarrh of the middle ear on both sides, on one side several sclerosed spots in the vestibule, many pigment cells in the cochlea, and numerous otoliths in Corti's organ. In the sacculi of the vestibule on each side there may be large, blackened accumulations of calcareous matter. The auditory nerves may remain normal. Musical sounds may be heard well during life in such cases, because the cochlea is less affected than the vestibule (Lucae: *Archiv für Ohrenheilkunde,* Bd. xv., p. 273). It was supposed in a case like this, reported by Lucæ, that the changes in the internal ear were due to inflammation in childhood. The nature of the inflammation was supposed to be hæmorrhagic, as shown by the deposit of pigment in the cochlea.

In another case, observed by the same writer, the whispered voice could not be heard, but the *c'* tuning-fork could be heard perfectly. At the autopsy it was found that the conducting apparatus and the labyrinth were normal, but that the acoustic nerve was gray and atrophic in appearance. Microscopic examination of sections of the auditory nerve showed that while the fibres of the *ramus vestibularis* were mostly normal, the *ramus cochlearis* showed very thin atrophic fibres, with considerable atrophy of the medullary sheath. It is supposed that in such cases a certain set of the fibres of the auditory nerve, corresponding in their power of audition to *c'*, had still preserved their function. Similar symptoms, often seen in deaf patients, may thus be explained.

HÆMORRHAGIC INFLAMMATION OF THE LABYRINTH IN CHILDREN.—Closely allied to hæmorrhagic processes in the cochlea, just described, are hæmorrhages and hæmorrhagic inflammation of the labyrinth in children, as described and demonstrated by post-mortem examination (Lucae: *Virchow's Archiv,* Bd. lxxxviii., 1882. Review in *Archives of Otology,* vol. xi., p. 245). A boy three and a half years old was affected with symptoms of a mild cerebro-spinal meningitis. On the tenth day he had begun to manifest symptoms of improvement, but the day after he became suddenly deaf. For three days preceding this he had complained of intense tinnitus aurium. Symptoms of meningitis, with strabismus, now returned. Three weeks after the relapse the patient was emaciated, insensible, and vomiting. Eight weeks after the beginning of the illness the patient died in consequence of an apparent tubercular basilar meningitis. The post-mortem examination revealed signs of internal hydrocephalus and a tendinous thickening of the pia mater at the base of the brain. The dura mater covering the petrous bone was reddish, blue and green in its discoloration, especially in the region of the semicircular canals. The osseous semicircular canals, especially the superior and the posterior, were filled with fluid blood and dark-red coagula. The vestibules also were filled with blood; the cochleæ contained less. Pus was found in the canals and in the broken-down membranous parts of the labyrinth generally. The vessels of the *laminæ spiralis* were greatly congested, and Corti's membranes in both cochleæ very much thickened. There were no evidences of tubercles in the labyrinth.

Careful examination seemed to show that the disease had reached the labyrinth by means of a reduplication of the dura mater, very rich in vessels which extended into the hiatus subarcuatus, *i.e.*, the space underneath the superior semicircular canal, which exists in children, not yet having been filled up by bony tissue. There was also an osteo-myelitic condition of the spongy substance of the bone about the labyrinth, which had induced the hæmorrhagic inflammation of the membranous labyrinth. Lucae thinks that he has discovered a way of transmission of inflammation from the meninges to the labyrinth, through this fossa subarcuata, heretofore unexplained, and by this means perhaps many cases of sudden deafness in children can be elucidated. It should, however, be borne in mind that Schklarewsky (*Göttinger Nachrichten,* No. 15, 1872) called attention to a similar way for the passage of inflammation from the semicircular canals, when experimenting upon them in animals, in the study of the functions of these organs, as alluded to by Boettcher in his experiments (Dorpat, 1872–73). In another male child, seven months old, similar hyperæmia and extravasations were found in the enormously enlarged narrow spaces of the spongy osseous portion of the labyrinth, and in the bony canals. This condition was attributed to the vascular connection between the fissura petro-squamosa and the dura mater, and thence to the labyrinth, by means of the vasa subarcuata. To this spongy tissue surrounding the capsule of the labyrinth, as well as to the vessels penetrating the petrous bone, an important part in the physiological nutrition of the labyrinth and its disturbances in infancy is ascribed.

PRIMARY ACUTE PURULENT INFLAMMATION OF THE LABYRINTH, RESULTING IN PURULENT MENINGITIS.—The occurrence of an idiopathic, primary, non-traumatic inflammation of the labyrinth seems to have been described, and satisfactorily demonstrated, by post-mortem examination of the labyrinth of a woman thirty-two years old (Schwartze: *Archiv für Ohrenheilkunde,* Bd. xiii., pp. 107 to 112, 1877). The first marked symptoms were aural, and consisted in pain in the right ear, with vertigo and uncertainty of gait. Several weeks previous to the occurrence of the pronounced ear-symptoms there had been pain in the right temple and brow, with anorexia and insomnia. Gradually the sense of fulness of the ear increased, the hearing became diminished, and vertigo, with tinnitus, became more distressing. At first, the headache and vertigo were relieved by rest and elevation of the head in bed. For a month the symptoms of headache increased, and vomiting often occurred. At the end of this time, the tinnitus and pain in the ear grew worse, the sleep was destroyed, and vomiting became more frequent. In the course of four days the patient had become pale and weak; the pulse was 72, temperature 37.8° C., and the gait more uncertain; the pupils were normal, but somewhat sluggish to the stimulus of light; the ear and its neighborhood were not sensitive to pressure; the membrana tympani was perhaps hyperæmic, and the hearing had diminished to only fifteen centimetres for a watch. The tuning-fork was heard better *per ossa* in the affected ear than in the unaffected one. There then ensued a period of relief from all the symptoms of pain in the ear and headache for a day, which was succeeded by a sudden increase of suffering. The headache became much worse, increasing in the temple, brow, and occiput of the affected side, and the pupils were wide but sluggish; pulse, 68, hard and full, and vomiting occurred. In the course of ten or twelve hours, sleep, from which the patient could be aroused, ensued, and there were some jactitations, with trismus, light delirium, and a pulse of 92. On the next day there was coma, with a pulse of 120, and the urine had to be drawn with a catheter; stertor, trismus, and narrowing of the pupils ensued, preceding death, which occurred without convulsions or paralysis of the extremities.

Post-mortem examination, in Schwartze's case, made twenty-five hours after death, revealed a thin calvarium, and the dura mater moderately injected, tight, and smooth. The pia mater was infiltrated with a greenish-yellow pus on the convexity, along the course of the large vessels, markedly so on each side, near the fossa of Sylvius. The gyri were mostly free. On the base of the brain the same purulent infiltration was found. The brain substance was soft, moist, moderately red, and near the ventricles especially soft. About the right Gasserian ganglion there was found some puriform matter between the dura mater and the petrous bone. The surface of the bone was unaltered, and elsewhere the dura was unchanged. The *sinus cavernosus* contained an old, brown clot, without pus. The *sinus transversus* and the *sinus petrosus superior* were empty. No pus was found on the nerve-trunks in the *porus acusticus inter-*

nus. The petrous bone was normal externally, no caries nor deficiencies of ossification being found in it. No cause of death was discoverable in the organs of the abdomen or thorax. The membrana tympani was not perforated, its mucous layer was thick, the tympanic cavity was healthy and free from pus. In the cochlea, in the vestibule, and in the semicircular canals there was found a sero-purulent fluid, of a milky appearance, which, upon microscopic examination, proved to be very fatty pus-cells. The vessels in the semicircular canals, and especially in their ampullæ, were intensely congested and tortuous. At some points in these structures there were small ecchymotic spots. The sacculi in the vestibule were greatly swollen, very red, and infiltrated with pus.

The occurrence of such an idiopathic, purulent inflammation, has never been so satisfactorily proven by demonstration of the pathologico-anatomical lesion as in this case of Schwartze's. The course of the passage of the inflammation of the labyrinth to the cranial cavity was not clearly demonstrable. It is known that it did not pass by the way of the nerve-trunks in the porus acusticus internus, nor are we warranted in supposing that the suppuration of the pia mater was primary and that of the labyrinth secondary, from the history of the onset of the symptoms and also from the freedom of the aforesaid nerve-trunks. It must be remembered that the first symptoms were aural, viz. : a sensation of fulness in the ear, pain, hardness of hearing, and tinnitus. Then followed vertigo and disturbed equilibrium, symptoms of irritation in the labyrinth. Several days later, there ensued symptoms of acute purulent meningitis. Syphilis could not have well been the cause, as no traces of constitutional syphilis were found elsewhere in the body, although the woman is known to have had syphilis a year previous to the labyrinth-disease. The congestion of the membrana tympani observed during life was due to its participation in the congestion of the tympanic cavity, induced by the suppuration in the labyrinth. Congestion of the tympanic cavity often occurs secondarily to suppuration in the labyrinth, following inflammatory processes in the cranium, or tympanic congestion may occur as a consequence of meningitis and an extension of the same by means of processes of the dura mater entering the drum-cavity.

OTITIS LABYRINTHICA : ACUTE INFLAMMATION OF THE MEMBRANOUS LABYRINTH.—In some respects closely resembling the otitis interna of cerebro-spinal meningitis, is an acute inflammation of the membranous labyrinth, described and denominated by Voltolini, otitis labyrinthica (*Monatsschrift für Ohrenheilkunde*, 1872, No. 8). There have been observed and reported by him some cases of a disease closely resembling acute meningitis, in young children, which he claims to be a disease of the labyrinth peculiar to children and as "specific as croup." From a close study of these cases, it would seem that there may be an idiopathic disease of the internal ear, viz. : of the labyrinth, closely resembling in its symptoms meningitis, but lacking the fatal result of the latter. The patient, however, is rendered permanently deaf.

Symptoms.—A child five years old with perfect hearing, may be attacked suddenly with vomiting which lasts for several days, with intermissions, and there will also be chill and fever. No cause can be assigned for these symptoms by the parents. On the first day of the disease the child still hears, but by the second day, the hearing is wholly destroyed. The intellect remains clear during the entire disease. Spasms, paralysis, and opisthotonos are absent. The urine and the fæces present no abnormal symptoms. The child may cry out that the noises in the head are distressing. By the fourth day the appetite returns, and the child begins to play. Upon attempting to walk, in the course of two or three weeks, the gait is very unsteady and the child has to be led about. An examination of the external auditory canal and membrana tympani reveals no alterations to account for these distressing symptoms. As death has never occurred in any of these cases, the precise lesion has never been demonstrated. There are some points of differential diagnosis worthy of mention. In cerebro-spinal meningitis, convalescence is long and herpes labialis is an almost constant symptom, while it rarely appears in otitis labyrinthica. The latter disease is ushered in by vomitings, which are absent in cerebro-spinal meningitis. Then, too, the hearing is quickly and entirely destroyed in otitis labyrinthica, while in cerebro-spinal meningitis it is destroyed much less rapidly and partial audition for some cracking and grating sounds seems to remain in many instances. It has never been claimed that treatment is of any avail in these cases of so-called otitis labyrinthica.

Gottstein maintains that the majority of cases presenting symptoms of a so-called primary otitis labyrinthica of Voltolini are really secondary, and usually the results of cerebro-spinal meningitis, the symptoms of the meningitis being overlooked, owing to the peculiar course of the disease. There may be assumed to have been in these cases an abortive form of cerebro-spinal meningitis, which, as it never proves fatal, has never been demonstrated by post-mortem evidences. Again, many cases of so-called otitis labyrinthica present the clinical type of mild cerebro-spinal meningitis. The strongest argument that the so-called otitis labyrinthica is a form of cerebro-spinal meningitis is that it occurs during epidemics of the latter disease. Lastly, the symptoms of meningitis always precede the auditory symptoms, as in the case of other nerves affected by meningitis (*Archiv f. Ohrenh.*, xviii., p. 174, and *American Journal of Otology*, vol. iii., 329).

CEREBRO-SPINAL MENINGITIS : DISEASES OF THE AUDITORY NERVE AND ITS TERMINAL PARTS.—At the termination of cerebro-spinal meningitis, or during convalescence from it, the patient is found to be deaf, usually in both ears. There is also in many cases an alteration in the gait, the patient assuming a sailor-like manner of walking, and there may be, in some instances, vertigo. The lesion in most cases lies in the labyrinth, and is due to a neuritis descendens, *i.e.*, a slow encroachment of the inflammation in the interior of the cranium, upon the labyrinth, along the perineural vessels of the auditory nerve. It is held by Moos (*Ueber Meningitis cerebrospinalis epidemica, insbesondere über die nach derselben zurück bleibenden combinirten Gehörs- und Gleichgewichtsstörungen*, Heidelberg, 1881), that in sixty-four cases observed by him in eighteen years, fifty per cent. showed disturbances of both equilibrium and hearing, fifty-nine per cent. were totally deaf in both ears, and hence became deaf-mutes, 31.4 per cent. were totally deaf but retained speech, while only 1.5 per cent. escaped without aural lesion. He also observed that those left with hearing for high notes, but with dulness of hearing or absolute deafness for low notes, stand a better chance of retaining hearing for spoken words. If absolute deafness persists for more than three months after the cerebral disease, the prognosis is unfavorable, without exception. If, however, subjective sensations of sound reappear during convalescence, provided the hearing has been previously wholly lost, the prognosis becomes more favorable. The disturbance in equilibrium, subsequent to cerebrospinal meningitis, is very probably due to an invasion of the semicircular canals and their ampullæ.

It is a noteworthy fact that those who become deaf in consequence of cerebro-spinal meningitis hear some noises like the cracking of a whip, or sharp, grating sounds, but are unable to hear the sounds of the human voice.

Sometimes the terminal expansion of the auditory nerve is compromised in the early inflammatory process. Then in a few hours the hearing is destroyed, and at the autopsy it is found that the vestibule, the cochlea, and the semicircular canals are filled with ecchymoses, blood, and pus, which explains the affection of the nervous elements (Kirchner: *Deutsche med. Wochenschrift*, 1884, No. 5).

In some instances the mucous membrane of the tympanic cavity is swollen and inflamed. In such a case the deafness may not depend entirely on a lesion of the terminal parts of the acoustic nerve, but upon purulent extravasation in the drum-cavity, or inflammation and cicatrization of the auditory ossicles.

From the investigations of Moos and others the following conclusions seem warranted: "1. The centre of the sense of equilibrium is in the cerebellum. 2. The ultimate nervous apparatus in the ampullæ, possibly also in the sacculi, is in connection with this centre of nerves. 3. Disease or irritation of this ultimate, terminal apparatus, or of tissues near it, may produce the same symptoms as a disease or irritation of the central organ itself. This is true of the symptom of dizziness. 4. Unilateral labyrinthine affections, whether they occur primarily or by extension of disease from the cranial cavity, manifest themselves by dizziness. 5. If in the same patient the other internal ear becomes affected, the new labyrinth-disease begins with dizziness, and is followed soon by a staggering gait. 6. Unilateral, sudden paralysis of the nerves of the ampullæ produces no dizziness. 7. The same holds good in regard to destruction of the nervous apparatus of the vestibule, when it occurs in chronic disease. 8. Bilateral, acute, hæmorrhagic, or purulent inflammation of the nervous apparatus, with permanent paralysis of the same, especially when the result of cerebro-spinal meningitis, produces a long-continued staggering gait. Children and those adults who have also disease of the eyes, are affected more severely and for a longer time. As soon as the muscles and the eyes act independently the staggering gait disappears."

Treatment.—Charcot has proposed to treat the dizziness and staggering by large doses of quinine. His plan consists in beginning with thirty centigrammes of the sulphate of quinia, and gradually increasing, till one gramme is taken daily. This method of administration of the drug may be kept up a month; then the treatment is stopped for a fortnight, to be resumed for another month. Charcot's theory of the mode of action of the quinine in such cases is that it destroys any remaining functional activity of the auditory nerve or its termini. This theory is not accepted by Moos, who claims that quinine, which he has administered with success in these cases, acts simply by antagonizing the inflammation, a view essentially rational and undoubtedly correct.

In those cases in which the hearing is not entirely destroyed, the application of the constant electric current to the ears offers some hope of benefit, if carried out soon after convalescence from the original malady; but if delayed many weeks, there is little encouragement to make the application.

Syphilitic Disease of the Labyrinth.—Sudden, total, and permanent loss of hearing is characteristic of disease of the internal ear, induced by syphilis. In most instances of such suspicious loss of hearing there are other evidences, perhaps a well-authenticated history, of acquired or hereditary syphilis. Such an affection of the ear must be regarded as a secondary manifestation of the blood-poison.

The lesion in these cases has been found to consist in sclerosis of the osseous substance of the petrous part of the temporal bone, and in anchylosis of the stapes in the oval window (Moos: *Virchow's Archiv*, Bd. lxix., H. 2). The chief lesions, however, in such cases, lie in the labyrinth, and are well marked. The periosteum of the vestibule may be thickened, the stapes foot-plate thickened, and hence anchylosed in the oval window, and the connective-tissue supports between the membranous structures in the labyrinth and the wall of the osseous cavity containing them, hyperplastic and infiltrated with small cells. This exudation may consist of small round cells, with a few oval ones, containing a single nucleus, and placed very close to one another. It may be disseminated so that the periosteum of the *lamina spiralis ossea* and the *zona pectinata* shall contain less than the auditory tract of Huschke and Corti's organ. The latter may be so infiltrated as to be nearly invisible. The infiltration may be much more copious in the ampullæ and sacculi than in the membranous semicircular canals. The trunk of the auditory nerve may be intact. The internal ear may be affected by syphilis in four ways: 1, by direct lesions; 2, by propagation of lesions from the middle ear; 3, by lesions in the bones, *e.g.*, naso-cranial ostitis, caries of the mastoid, and especially caries of the petrous part of the temporal bone; 4, by reflection of central disorders upon the hearing. Cerebral syphilis is said to comprehend among its earliest symptoms disturbances in hearing, but these are rarely the only prodromes. These are generally the cerebral. The aural symptoms consist sometimes in subjective sensations, limited to one or to both ears, and again, they manifest themselves by a progressive hardness of hearing, which may culminate in entire deafness. They may, also, present all the phenomena of Ménière's disease. The prognosis is variable. Recognized at the outset, the disease can be influenced by specific treatment, according to some observers (Jegu: *Annales des Maladies de l'Oreille*, Mai, 1884).

The *treatment* of syphilitic affections of the auditory nerve, *i.e.*, of its labyrinthine distribution, even by large doses of iodide of potash or sodium, is probably of no avail (A. H. Buck). Those cases of reported cures of syphilitic deafness due to disease of the cochlea or any other part of the percipient organs of hearing, it is highly probable, were cases of affection of the middle ear, and hence more or less remediable.

Concussion of the Terminal Filaments of the Auditory Nerve in the Labyrinth.—Concussion of the labyrinth may ensue from a fall, a blow upon the ear or head, or from the effects of an explosion or the discharge of firearms near the ear. The symptoms of concussion are instant tinnitus, and a feeling of fulness, with more or less deafness of a profound nature, in one or both ears. Sometimes, after concussion of the labyrinth, there may be a peculiar, subjective, metallic, "echo-like" termination of the words spoken by the patient and others (L. Blau: *Archiv für Ohrenh.*, Bd. xv., p. 225, and G. Brunner: *Archives of Otology*, vol. ix., p. 339). In some instances of concussion of the labyrinth from a fall, as from a horse, there may be temporary paralysis of the sense of smell. In most instances there is no evidence of any lesion in the external or middle ear. Sometimes, however, there are slight hæmorrhages from the meatus immediately after the concussion, its force having been partially spent upon the tissues of the fundus of the auditory canal and membrana flaccida. The deafness may affect both ears at first, one of which may recover; or if only one ear is affected at the outset, a partial recovery in it may ensue. If, however, the deafness is profound from the outset, the chance of recovery of the hearing is very slight. How the deafness is produced in these cases of concussion is the subject of different views. Some maintain that a dislodgment of the terminal filaments of the auditory nerve occurs in and about its supporting apparatus, the so-called organ of Corti, and that such displacement permanently abrogates the auditory function of all the parts thus jarred. On the other side, it has been urged that the result of the concussion is a more or less copious hæmorrhage into the labyrinth. This view seems the more probable, from the fact that in some cases the hearing is largely, if not entirely, restored. It is maintained that in such cases the hæmorrhage producing the alterations in hearing is absorbed before it has effected a permanent lesion upon the nervous elements of the labyrinth. In cases of concussion of the brain, it is maintained that the fatal issue is produced by more or less numerous and minute hæmorrhages throughout the cerebral substance. As a matter of fact, minute ecchymoses are found throughout this region in the cases of fatal concussion.

It is further asserted (Duret, C. K. Mills, and others) that these small hæmorrhages are produced by the force of the blow, communicated to the cerebro-spinal fluid, and thence throughout the surface of the brain and parts of the spinal cord. Since the cerebro-spinal fluid supplies the lymph-fluid to the internal ear, it can be easily seen how the force of a concussion of the head may be communicated thus to the labyrinth and its vessels, causing minute ruptures in them, or extravasation from them into the membranous parts of the internal ear, and consequent pressure upon the terminal auditory filaments. This would produce instantaneous tinnitus and hardness of hearing, the latter more or less profound, according to the quantity of the effusion, and dependent for its

duration upon the promptitude or slowness of the absorption of the extravasation.

Such an hypothesis seems to be the only efficient explanation of the mode of the occurrence of the aural lesion from concussion, as well as of the recovery of hearing which sometimes ensues after having been profound and undoubtedly due to commotion of the nerve in the labyrinth.

Treatment.—The treatment should consist in the administration of the iodide of potash, the bromides of potash and sodium, ergot, and in counter-irritations, the latter to be placed of course near the affected ear.

Effects of other Forms of Traumatism upon the Internal Ear.—Sudden and permanent deafness, with facial paralysis on the injured side, may be produced by a stab-wound in the temporal region between the eye and the ear, as in a case reported by Moos (*Archives of Otology*, vol. x., p. 17). In this instance there was also a temporary irritation of the oculo-motor and vagus nerves on the side of the affected ear. The phenomena of deafness and facial paresis here were explained by the supposition that a fissure had passed through that part of the petrous bone, including the first bend of the facial nerve and the osseous cochlear capsule. There were other symptoms which were accounted for by the supposed occurrence of extravasation of blood in the internal ear. These consisted in the perception of the tuning-fork, by bone-conduction and by the air, only in the unaffected ear. The same was true for the watch and the acoumeter. The hearing was completely destroyed on the side of the stab-wound. There was, however, in the ear on this side, the left, a slight but constant tinnitus, at first occipital, but gradually referred to the affected ear, and at last it became more intense. Finally, there ensued in this case an improvement in hearing, at first noticeable in connection with high notes, then for lower ones.

Moos expresses the opinion that, if there be assumed a fissure in this case, in the region of the first bend of the facial nerve and the adjoining region of the cochlear capsule, together with an exudation or extravasation, we can explain the successive improvement in the hearing of, first, the higher, then the lower notes in the scale, on the theory of Helmholtz, which is, that the nerve-fibres nearest the round window serve for the perception of high notes, and those near the cupola for the low ones. It is to be supposed that in this case the extravasation or exudation nearest the round window was less copious than elsewhere, and hence more easily absorbed.

In addition to the total deafness and tinnitus which supervene instantly upon concussion of the labyrinth from the near discharge of firearms, or other causes, there may be very loud noises in the head, headache, vertigo, insomnia, and great nervous excitement. In the course of two or three days there may be considerable feverish disturbance in the general system. The ability to distinguish musical notes, as such, may be entirely abrogated, though the impact of the key upon the wires is perceived as a thud or noise (Gustav Brunner: *Archives of Otology*, vol. ix., p. 337). In such an instance, according to the prevailing theory that in the cochlea lie the parts of the nerve percipient of music as such, it can be assumed that the force of the concussion has produced a lesion in the cochlea, and the form of this is either an exudation or extravasation of some of the sanguineous elements, or of pure blood.

The quality of the sound of the voices of others may be greatly altered, so that they are heard very indistinctly, and almost grotesquely altered, especially in so-called nervous people. It is even asserted that the phenomena of concussion of the labyrinth may be induced by violent sneezing (O. Wolf: *Arch. of Oph. and Otol.*, vol. iv., p. 273). When the concussion has affected both ears, the patient may hear the tuning-fork half a tone higher, when held before one ear, than before the other. In Brunner's patient the fork was heard higher in the ear which had been most exposed to the force of an explosion. This phenomenon, however, is explained by the assumption that the explosion caused a difference in tension of the membrana tympani in the two ears, *i.e.*, the explosion, by forcing the left membrana further inward than the right, rendered the former, by virtue of its greater tension, more sensitive to high notes, and it therefore conducted the high partial tones of the note of the tuning-fork better than the right membrana tympani.

Permanent deafness may ensue after a blow upon the temple, as in the case of a boy, nine years old, who was struck at this part of his head with a spoon in the hands of another boy. There immediately occurred violent bleeding from the nose and vertigo, all signs of which disappeared in a few days. Nine days later, though having heard well, he awoke one morning entirely deaf in both ears, and remained so. It was supposed by Urbantschitsch, who observed the case, that hæmorrhage occurred in the region of the fourth ventricle, or in the medulla oblongata. He refers to Duret's experiments, which show that this can happen from a blow on the head (*Archiv f. Ohrenh.*, Bd. xvi., 3).

Nerve Atrophy in the Labyrinth.—*Nerve atrophy in the first cochlear whorl.* Further evidence that the lower whorls of the cochlea contain nerve-fibres especially percipient of higher notes of the scale, is afforded in cases of nerve atrophy in these portions of the labyrinth. In a man who had died of carcinoma of the brain and stomach, and who had been for some time entirely deaf for higher tones in his right ear, microscopic examination revealed a normal condition of the central termination and trunk of the auditory nerve, with the exception of a few minute atrophic spots; but in the cochlea, while the nerve-fibres in the two upper whorls were perfectly normal, those in the first or lower whorl had undergone a marked quantitive atrophy (Moos and Steinbrügge: *Archives of Otology*, vol. x.). Since Helmholtz and Hensen locate the shorter fibres of the acoustic nerve in the lower whorl of the cochlea, and the larger ones nearer the cupola, and as the shorter fibres respond to higher notes in the scale, the atrophy in these fibres will account for the deafness for high tones in this case; while pressure at this point, from exudations and extravasations of blood, could account for similar phenomena in others. (See Concussion of Labyrinth.)

Atrophy of the trunk of the nerve or its branches may occur as a secondary result of "disease of the brain near the origin of the nerve, from disease of the cerebellum, fourth ventricle, and medulla oblongata; from hydrocephalus internus; from apoplexy and softening of the brain, or from atrophy of those parts to which it is distributed, *i.e.*, the ultimate nervous apparatus. Atrophy from this latter cause appears to be developed often from loss of function of the peripheral conducting apparatus. It is also caused by the pressure of tumors at the base of the skull, by tumors of the brain, by extravasations of blood in the *porus acusticus internus*, by periostitis of the *porus acusticus*, and by neuritis" (J. O. Green's translation: Schwartze's "Pathology of the Ear," 1878).

It is claimed by several authorities that alterations in hearing occur in connection with tabes dorsalis, as a pathognomonic symptom (Buzzard, Erb, Duchenne, Bourdon, and others). Among other crises in tabes dorsalis, Buzzard thinks the auditory nerve may be specially affected. He quotes from Pierret, who held that the auditory nerves are frequently affected in tabes dorsalis (*Lancet:* September 24, 1881). Buzzard maintains that the frequency of this symptom has not been duly appreciated. Since Pierret called attention to this aural symptom in tabes, the former has had constant occasion to observe more or less deafness in cases of tabes, "sometimes only of a passing character." Ormerod observed thirteen cases of tabes, in which five manifested more or less deafness (Buzzard: *loc. cit.*). The aural phenomena ensuing in tabes dorsalis are held to be due to atrophy of the auditory nerve (Erb). Lucae, who, according to Schwartze, is the only one who has made accurate dissections of the ear in cases of gray degeneration of the cord, says he found no degeneration in the auditory nerve. I have observed several cases of tabes dorsalis in which, with the early symptoms of the spinal disease, there were associated tinnitus aurium, diminished hearing, and opacity of the membrana tympani. The aural symptoms could not be

easily accounted for, excepting as being concomitant and dependent upon the spinal complaint, the latter apparently having induced nutritive disturbances and changes in the organ of hearing.

It is claimed by some authorities that disturbances in hearing, dependent upon lesions in the internal ear, are among the premonitory symptoms of syphilitic tabes. The symptoms in such cases are noises in the ear, of various qualities, and sometimes all the phenomena connected with Ménière's disease. Their duration is limited, and they may disappear more or less completely (Jegu: *Annales des Mal. de l'Oreille*, etc., Mai, 1884).

A centripetal progressive atrophy is said to be often developed from long-continued loss of function in the conducting apparatus of the ear, especially from anchylosis of the stapes, associated with immobility of the membrane of the round window; but it is not claimed that it is a constant result (Schwartze). Atrophy of the nerve may be associated with inspissation of pus in the cavities of the labyrinth (Haighton). Tumors, by forcing themselves into the internal auditory meatus, produce atrophy of the trunk of the auditory nerve, and also of its terminal parts in the labyrinth, as in a case observed by Morris Longstreet and Charles H. Burnett (Burnett's "Treatise on the Ear," second edition, 1884, pp. 558–562). In this case there was a tumor, probably sarcoma, in each auditory nerve. On the left side, behind the petrous bone, below the tentorium, was a large tumor pressing on the left hemisphere of the cerebellum, left half of the pons, and left crus cerebri. The nerves springing from the left side of the *medulla oblongata*, passed on the under surface of the tumor, were flattened by it, and somewhat adherent to it. The seventh nerve (auditory and facial) was tightly adherent to the tumor, by which it was so much flattened as to be transparent. The facial could not be separated from the auditory nerve, as their consistence was so much reduced, and they were so adherent. The tumor measured 5 ctm. (two inches) transversely, and 4.50 ctm. (an inch and three quarters) antero-posteriorly. It was lobulated, and made up of cysts with solid intervening partitions. The cystic parts were reddish; the other parts firm, white, and opaque. It extended with the auditory nerve into the left internal auditory meatus, which had become considerably widened. After the brain had been removed there was found another tumor, resting upon, and adherent to, the posterior surface of the right petrous bone. It was oval in shape, 1.50 ctm. (five-eighths of an inch) long, and 1.1 ctm. (about half an inch) in its vertical diameter, and of doughy consistence. It was attached by a sort of pedicle, which extended into the right internal auditory canal, and the auditory nerve was more intimately connected with it than the left tumor was with the auditory nerve on its side. The auditory nerve seemed to run under it, to reach the porus acusticus internus, which was widened by the encroachment of the growth. The bone was not exposed, the dura mater being still adherent, but thinned. The right auditory nerve seemed of normal size and consistence from its origin. Upon microscopic examination of numerous sections, the tumors proved to be spindle-celled sarcomata, with a number of small cells and granulation-like tissue mixed with the spindles.

Microscopical examination of the left cochlea revealed a normal modiolus, but the spaces in its substance, normally occupied by branches of the cochlear nerve, showed no traces of nerve-fibrillæ or ganglia. Many of the spaces contained granular and fatty detritus, showing in its midst a few fine fibres, by which this was held in connection with the walls of the spaces. Other spaces were nearly empty, showing at most a scanty fibrous network. A number of vascular lumina, with corpuscular contents, were plainly visible. The lamina spiralis ossea was normal in shape. The space between its lamellæ contained no trace of nerve-tissue, but was occupied by a very fine fibrous material, containing in it much less granular matter than similar tissue in the spaces of the modiolus, with which it was continuous. The membrana basilaris was not sufficiently preserved to admit of particular description. Pieces of it which were examined showed no marked changes. No traces of Corti's organs could be found. The ligamentum spirale of Henle was normal in appearance. The lining cubical epithelium of both scalæ was very distinct, and presented a smooth, even surface. The bone at all points presented perfectly normal conditions.

Microscopic examination of the right cochlea showed that the tumor had grown deeper into the internal auditory meatus, the walls of which were atrophic by pressure, and the canal thus widened. This atrophy extended markedly toward the base of the cochlea, reaching close up to or into the modiolus, where parts of the tumor in mass could be seen. Consequently, the bony portions between the scalæ and the fundus of the internal auditory canal were rendered thin. The modiolus was not of normal form, and differed in shape also from that shown in similar sections from the opposite cochlea. The alteration was more noticeable in parts nearer the summit, and was due partly to new material which extended into the scalæ, and partly to a change within the bone itself. Neither the number nor the size of the vessels in the modiolus was increased. The ganglionic spaces in the modiolus, on the right side, were very different in appearance from those on the other side, as they contained either a granular amorphous material, or cell-structures. No new fibres were detected. Near the junction of the lamina spiralis ossea with the modiolus, these spaces became larger and the cellular nature of their contents more distinct. No nerve-elements were found emanating from the lamina spiralis ossea. At the habenula perforata, no nerve-fibres were found. In no section of the cochlear canal could Corti's organ be found. There seemed to have been atrophy of the nerve-elements entering the cochlea.

Symptoms.—In this case the symptoms are worthy of note. The patient, a woman forty-two years old, had always been well until within fourteen months of her death, when she had taken a severe cold in her head. She also began to have pain in her forehead and vertex. Nine months later, she began to grow deaf very rapidly; tinnitus aurium supervened, with unsteadiness of gait, pain in her limbs, impairment of sensation in the legs, vertigo, and occasional nausea. There had never been any loss of power in the limbs nor muscular trembling. In thirteen months from the first failure in health, it was noted that in walking there was a tendency to fall toward the right, and it was found that she had fallen several times. Vertigo could be produced, when in the upright position, by closing her eyes, but she was entirely free from it when lying down. There was great pain in the head, generally referred to the vertex and to the forehead over the eyes. The tinnitus aurium continued to be intense and annoying, worse in the morning. There was nausea, but no vomiting. There was still no loss of power in the limbs, nor paralysis of any of the other cranial nerves, and no disturbance of sensibility. She was very deaf. There was no history, nor even suspicion, of syphilitic taint. There was nothing in the middle, nor external ear, to account for the aural symptoms, all these parts being normal. The right ear was not as deaf as the left, on which latter side the larger tumor lay. At last, in the course of a year, there were increased headache, vertigo, falling with inability to rise, general loss of power to assist herself, and finally, confinement to bed. Then there ensued loss of power over legs, failure of intellect, and difficulty of swallowing. The muscles of the eyeball prolapsed; the pulse and respiration increased in frequency. There then set in cyanosis of the face, involuntary passing of the urine, and impaired sensibility of the extremities, followed by unconsciousness and death, with a temperature of 106° F. a few hours before her demise.

Histological Changes in the Labyrinth in Typhoid Fever, Scarlet Fever, and Variola.—In typhoid fever the entire labyrinth is often affected upon one or both sides. The parts more usually affected are the utriculus, the sacculus, the ampullæ, and the lamina spiralis membranacea. The semicircular canals and the zona ossea are less frequently implicated. Histologically, the affection consists in a small-celled infiltration, *i.e.*, an

infiltration of small lymphoid cells (Moos: *Archives of Oph. and Otol.*, vol. v.). In one case Moos found, besides these, an infiltration of cells containing fat-granules, in equal number and dissemination with the small lymphoid cells. Whether this inflammatory process in the labyrinth is to be regarded as a specific lymphatic formation, peculiar to the typhoid disease, as occurs in other organs in this affection, or simply as an extension of inflammation from the tympanic cavity simultaneously affected with purulent inflammation, could not be decided. In one case, however, this small-cell infiltration was found throughout the entire labyrinth, where only a non-purulent catarrh existed in the tympanic cavity, with inflammation of both membranæ tympanorum.

It is held by this observer, that this affection of the labyrinth may end in purulent inflammation, or that fatty degeneration and complete absorption of the exudation may ensue. Or there may result opacities, thickenings, or atrophies of the tissues attacked; perhaps, too, cheesy necrosis or ulceration. These possibilities should be remembered in the explanation of disturbed hearing in typhoid fever, when only negative results are found by examination of the ear during life.

Labyrinth in Scarlet Fever.—In a case of scarlet fever, complicated with diphtheria of the mouth and fauces, suppuration of the parotid gland, otitis media purulenta, and periostitis of the left squama, and in which death occurred from secondary meningitis, Moos found ambilateral inflammation of the labyrinth (*loc. cit.*). The membranous sacs, and also the membranous semicircular canals, were more adherent than usual, the connective tissue being greatly increased between the bony walls and the membrana propria of the aforesaid membranous structures. The connective-tissue trabeculæ were enlarged and vascular, showing also a rich infiltration of round cells and some pus-cells. The small-cell infiltration, as well as the purulent, was diffused so greatly over the membranous sacculi, the ampullæ, and membranous semicircular canals, that the epithelium of their membrana propria was nowhere clearly visible. On the lamina spiralis ossea this was so extensive that the separate tracts of the delicate structures thereon could scarce be distinguished from one another.

This condition of the labyrinth was held to be an explanation of all those cases of great hardness of hearing or absolute deafness after scarlet fever, in which an analysis of the other clinical symptoms unconditionally excludes the supposition that a concomitant cerebral affection has caused the destruction of hearing.

It is claimed by Moos and O. Wolf, that the deafness resulting from labyrinth disease, induced by scarlatina, can be benefited by hypodermic injections of pilocarpin, as suggested by Politzer. Thus in the case of a little girl, seven years of age, who was affected by labyrinth-disease from scarlatina, as shown by total deafness for all sounds and altered gait, there were used injections of pilocarpin (pilocarpin muriat., 0.02 Gm.; aq. dest., 2.0 Gm.), first, ten drops at a time, but later, twenty drops at an injection. This treatment was endured very well, and seemed to exercise a beneficial effect upon the labyrinth affection. The hearing, though not becoming normal, was so far restored as to enable the child to go to school with hearing children, and keep up with them in her studies.

Purulent Inflammation of the Labyrinth in Variola.—Moos (*loc. cit.*) found in a child four years of age, who had died of variola, a purulent inflammation of the labyrinth in connection with otitis media purulenta, in both ears. As the stapedes were still in normal position in the oval windows, it may be assumed that the labyrinth suppuration was not an extension of the purulent disease from the tympanic cavity. Macroscopically, the semicircular canals, ampullæ, and sacculi were thickened and lemon-colored. Microscopically, there was found a copious new formation of connective tissue between the bony and the membranous labyrinth. The connective-tissue supports between these parts of the labyrinth were copiously infiltrated with pus, numerous pus-cells were found on the membranous sacculi, and still larger quantities upon the semicircular canals and their ampullæ. The zona ossea and zona membranacea of the cochlear whorls, on both sides, were covered with solitary and agglomerated pus-cells. The blood-vessels of the lamina spiralis membranacea were intensely congested, but the nerves in the internal auditory meatus were normal.

Pilocarpin in Diseases of the Auditory Nerve and Internal Ear.—Pilocarpin has been used by Lucae with advantage in several cases of disease of the internal ear, and the results have recently been published (*Archiv für Ohrenh.*, Bd. xxi., pp. 280 to 290. Jacobson's Bericht).

In a case of acute disease of the sound-perceiving apparatus following emansio mensium, a cure was effected by using pilocarpin in subcutaneous injections after the administration of bromide and iodide of potash, the use of the catheter, and other anticatarrhal remedies for two months, had proved of no value. The symptoms were tinnitus aurium and hardness of hearing, for which the patient could give no cause, excepting that her menses, previously exact, had failed to appear at the regular time, and that instead the aural symptoms had set in. In five weeks thirteen subcutaneous injections of pilocarpin were given, after other remedies had failed. At first the injection contained 0.005 Gm., which, not being endured by the patient, the quantity was reduced to 0.0025 Gm. on each injection. After the fifth injection the hearing improved a little and the menses were established, which, after lasting two days, were followed by further improvement in hearing. The hearing continued to improve, but the tinnitus aurium remained notwithstanding the use of the Eustachian catheter, bromide of ammonium, and the constant electric stream. It was suggested that, perhaps, the cause of the deafness consisted in a vicarious exudation (sanguineous) into the labyrinth.

In a second case, chronic disease of the sound-perceiving parts in the internal ear was greatly improved by subcutaneous injections of pilocarpin. The deafness and subjective noises, in this case, seemed to have been induced by working in a noisy factory. Negative symptoms in the middle ear, as revealed by the catheter and auscultation-tube. In twenty-three days fourteen injections of pilocarpin, 0.01 Gm., were administered. The hearing was improved, and the tinnitus aurium diminished by this medication. Pilocarpin has been used by Lucae with advantage in a case of Ménière's disease affecting both ears. Iodide of potash and hydrobromic acid did not prove efficient in the case; therefore, during a period of nearly two months, thirty-two subcutaneous injections of pilocarpin, 0.01 Gm. each, were administered. After five such injections the vertigo decreased, then, after some increase during a cold in the head, there was further improvement by the time the thirteen injections had been given. For a period of two weeks the injections of pilocarpin were suspended. As the patient then began to complain of a return of intense but variable tinnitus, with some increase in hardness of hearing, the pilocarpin injections (each 0.01 Gm.) were renewed for a period of six weeks, until twelve more had been given. The tinnitus, however, was not specially benefited by the final course of pilocarpin; but the vertigo disappeared entirely, and did not return. The hearing was permanently improved. In another case of ambilateral Ménière's disease, twenty-six pilocarpin injections (each 0.01 Gm.), administered in the course of about six weeks, produced no beneficial effect.

Internal Ear Affected by Mumps.—That the nervous apparatus of the internal ear is sometimes suddenly and permanently injured by the poison of mumps, the process being most probably a metastatic one, has been recognized and more or less minutely described by Toynbee and James Hinton, and still more recently by H. D. Noyes ("Transactions American Otol. Soc., 1879," p. 342), A. H. Buck (*ibid.*, 1881, p. 488), Calmettes (*France Médicale*, 22 Juillet, 1882), E. G. Moure (*Revue mensuelle de Laryngologie*, etc., 1882), H. Knapp (*Archives of Otology*, 1882, vol. xi., p. 232), J. Seitz (*Correspondenz-blatt f. Schweitzer Aertze*, No. 19, 1882), S. Moos (*Archives of Otology*, vol. xi., 13, 1882; *ibid.*, vol. xii., p. 321, 1883;

and *Berlin. klin. Wochenschr.*, 1884, No. 3), G. Brunner (*Arch. of Otology*, vol. xi., p. 104, 1882), Roosa (*Arch. of Otology*, vol. xii., No. 1, pp. 1 to 11), Chas. J. Kipp (*Arch. of Otology*, 1884, 116), Bürkner (*Berlin. klin. Wochenschrift*, No. 13, 1883), Seligsohn (*ibid.*, Nos. 18 and 19, 1883), Lemoine and Lannois (*Revue de Médecine*, No. 9, 1883), and by others in Europe and in this country.

In the case given by Noyes, the patient was a physician, thirty-eight years old. The mumps occurred on both sides, without much pain in the glands or the ears. On the seventh or eighth day the pulse fell to fifty per minute, the patient became dizzy on attempting to sit up in bed, and there were constant nausea and vomiting, though no headache. About this time tinnitus was observed in the right ear, and in the course of two or three days this ear became totally deaf. About the twelfth day the right testicle became inflamed, subsiding in a week, coincidentally with the cerebral and aural symptoms. The dizziness persisted for some weeks, and upon getting up from the bed the patient walked with difficulty. The ear was now found to be entirely deaf to all sounds, both by aërial and bone-conduction. The membrana tympani was normal, and there was no tenderness in the mastoid region. With his eyes closed, the patient swerved toward the left side, *i.e.*, away from the affected ear.

In a case narrated by Buck, in which the mumps were on both sides, and occurred in a girl, on the third day of the disease there was pain in the right ear, which lasted for a few hours, with unpleasant tinnitus. The next day the hearing was gone; the tinnitus continued in the right ear, but the left ear remained normal. The tuning-fork, vibrating on the vertex, was heard only in the good ear. There was entire absence of dizziness, nausea, and disturbed equilibrium. There was pharyngitis with closure of the Eustachian tube on the side of the affected ear, the cure of which was not followed by improvement in hearing. Nor did large doses of iodide of potash and counter-irritation behind the ear produce any benefit.

In a second case, by the same author, mumps, in a man forty-one years old, produced deafness in the left ear on the third or fourth day of the disease. There was at first a loud roaring in the entire head, but this finally became localized in the left ear. On the fifteenth day there were nausea and dizziness, and a difficulty in maintaining equilibrium. These symptoms increased for forty-eight hours, and then diminished in intensity. But the deafness remained profound and unchanged. The membrana tympani was normal, and the tuning-fork, by bone-conduction, was heard only in the unaffected ear. In both cases the hearing was lost on the third or fourth day of the mumps; in the first with aural pain, in the second without pain; but in both the subjective noises were distressing. In one instance, the deafness occurred on the side of the most affected gland. In the first case, though both glands were deeply affected, only one ear was attacked. In the second case, a second apoplexy, or metastasis, seems to have occurred on the fifteenth day after the primary lesion. The first seemed to be in the cochlea, while the second attack involved the ampullæ and semicircular canals, as shown by the symptoms of aural vertigo.

The age of the patient may be as low as six years, and after even very mild mumps, both ears may be attacked (Calmettes). Moure reports the case of a girl, eight years old, who suddenly lost the hearing in both ears on the fifteenth day of mumps. Or a young man, eighteen years old, may be attacked with aural symptoms on the sixth day of the disease, and in thirty-six hours lose the hearing entirely in one ear, with symptoms of tinnitus, vertigo, and altered gait (Seitz). Moos observed that, in a boy thirteen years old, the hearing was entirely destroyed on the fifth day of mumps, that vomiting set in on the sixth day, and that, on the eighth day, an alteration in the gait ensued. Consciousness was never lost, but the perception of speech was entirely lost in both ears. Perception by bone-conduction for the tuning-forks C and C′ was retained, but not that for the fork A′. It was supposed that in this instance some of the fibres in the cupola had escaped, but that others had been destroyed by the metastasis. Again, in a little girl four years old, the same author observed a total loss of hearing in both ears, on the fourth day of mumps, without other symptoms in the ear. When no disturbance in equilibrium occurs, the metastatic process is limited in all probability to the cochlea. Usually the aural symptoms consist in a simultaneous tinnitus aurium, vertigo, and deafness. The two former symptoms disappear sooner or later, but the deafness remains. These peculiar symptoms may not be developed until the fifteenth day, and then only after subsidence of metastatic processes elsewhere, as in the case of a young man, eighteen years old, in whom deafness set in, in the right ear, as a metastatic orchitis subsided (Charles J. Kipp). Usually there are no symptoms in the external or middle ear to account for the sudden deafness ensuing in the course of mumps. It must be borne in mind, that sometimes this form of deafness may take place in an ear previously altered in appearance, at least, by chronic catarrhal processes. But the suddenness of the deafness, its occurrence during mumps, and the usually attendant symptoms of tinnitus, nausea, vomiting, vertigo, and sometimes altered gait, will enable the physician to make the diagnosis of the true nature of the aural malady. It is worthy of note that mumps occurring in subjects of chronic aural catarrh do not seem to have any special tendency to affect the ear, as I have observed in my own patients.

Sometimes the pain in the ear, as well as that in the head, is great, as in a case reported by Lemoine and Lannois. The patient, a man twenty-three years old, a military recruit, was attacked by mumps on both sides during an epidemic of this disease. On the fourth day he experienced tinnitus in both ears, with a whistling sound in his head, and violent headache over the entire head and the fundus of the ears. He became then very deaf, first in the left ear and then in the right. There was entire absence of vertigo, dizziness, disturbed equilibrium, and nausea. The pharynx, Eustachian tube, and membranæ tympanorum were normal. Under varied treatment by mineral waters and alteratives, all the symptoms abated excepting the deafness, which remained absolute and unchanged.

Etiology.—It is supposed, in some instances, that the deafness and other aural phenomena are caused by a serous exudation into the labyrinth (Seitz). It is maintained (Moos) that in mumps, obstructions and secondary disturbances occur in the labyrinth, and that a basilar meningitis cannot be held to be the cause, when there has been no loss of consciousness nor any other meningitic symptom. Brunner maintained that there may be, in such cases of deafness after or during mumps, an inflammatory excitation of the labyrinth which leads to a rapid and copious exudation without inclination to suppuration. The short course, and the absence of disturbance in the general system, forbid the idea of suppuration. It does not appear strange that so rapid a process, in spite of its innocent character and its tendency to absorption, should have a destructive effect upon the delicate tissues of the labyrinth. Roosa maintains that an affection of the labyrinth may occur simultaneously, or by extension from the middle ear, during mumps. Also, that it is probable there are cases in which the disease (mumps) is transferred to the labyrinth in the same manner as are the inflammatory processes occurring in the testes and mammæ in the course of mumps. Such cases are not regarded by him as frequent. In a case observed by him, H. D. Noyes supposed that a metastatic inflammation, coincident with an orchitis, had invaded the labyrinth. Lannois and Lemoine place the auditory affections of parotitis among the rare occurrences in this affection. In the category of rare concomitants of mumps, they also cite prostatitis, mammitis, ovaritis, nephritis, cerebral accidents, and ophthalmic disorders, as optic neuritis with atrophy of the papilla. From the literature pertaining to this subject, it seems entirely warrantable to conclude that the process producing the deafness in mumps is a metastatic one, involving the labyrinth. A

few have thought the disease might reach the internal ear from the middle ear, or by the way of the facial nerve and its canal; but the absence of symptoms of middle-ear disease and of facial paralysis in the cases cited, prohibits such an assumption as to the etiology of this form of absolute deafness. No treatment has shown itself capable of either preventing the destruction of hearing, when the ear is first threatened, or of curing the deafness after it has become established.

Deaf-dumbness: The Nervous Lesion.—The lesion in congenital deaf-dumbness may be an early periostitis of the petrous bones (Moos: *Arch. of Otol.*, vol. iii., p. 193, 1872, and vol. viii., p. 137, 1879). This is shown by the sclerosis in the substance of the bones, anchylosis of the ossicles, the partial hyperostotic condition of the bony walls of the tympanic cavity, and closure of the fenestra rotunda. A colloid substance may be found in the labyrinth in such cases. In some instances, no trace of semicircular canals, ampullæ, nor cochlea, is found The auditory nerves may be atrophic and contain concretions of phosphate of lime. The facial nerves, emanating from different centres of development, may be normal. In such cases the auditory vesicle alone is arrested in development (Moos and Steinbrügge). In other cases an examination of the labyrinth, on both sides, reveals a large quantity of otoliths and numerous colloid bodies in the ampullæ, the sacculi, and on the lamina spiralis membranacea, with freedom from disease in the inner part of the internal auditory canals. The abolition of hearing is often directly due to colloid degeneration in the labyrinth.

In a case of acquired deaf-dumbness, Moos and Steinbrügge found the following histological changes:

The auditory nerves were of normal thickness, and on the right side the vestibule, semicircular canals, and cochlea were normal. On the left side numerous colloid globules and molecular detritus were found in the connective tissue of the utriculus, the semicircular canals, and the ampullæ. In other respects, these parts seemed normal. In the right cochlea the principal changes were in the first whorl. The nerve-fibres were wanting in the lamina spiralis ossea. Both scalæ were invaded by new-formed bone-tissue, more so in the scala vestibuli than in the scala tympani. The ganglia in the modiolus were in normal quantity, but they sent off only a few fibres to the osseous lamina. In this case there had occurred an inflammation of the entire labyrinth of the right petrous bone, in the fourth year of life. This process led to an exudation into the perilymphatic space of the semicircular canals, ampullæ, and vestibule, which finally underwent partly a colloid and partly a molecular degeneration. The results in the cochlea were a proliferation of connective tissue, and a new formation of bone proceeding from the periosteum. This process caused partial obliteration of the cochlear cavities in the first whorl, and fixation of the membranous lamina spiralis. Total ossification of the labyrinth may occur, as observed by Politzer (Otol. Congress, Milan, 1880). In the deaf and dumb there may also be found periostitis of the temporal bone, exostosis in the right drum-cavity, anchylosis of all the ossicles, on both sides, osseous closure of both round windows, osseous narrowing of the communication between the vestibule and cochlea, narrowing of the cavity of the bony labyrinth, calcareous masses in both internal auditory canals, and also in both membranous sacculi in both vestibules, but no further changes in the nervous apparatus (Moos: *Archiv f. Ohrenh.*, Bd. ix., p. 276).

Luys places the centre of hearing in the posterior regions of the cerebral lobes. This he attempts to substantiate by his discoveries in the post-mortem examination of the brains of deaf-mutes (*Annales des Mal. de l'Oreille et du Larynx*, 1875, pp. 313–322, and *Archiv f. Ohrenh.*, Bd. xi., p. 179, 1876). In one case, a man seventy-two years old, a congenital deaf-mute, but an intelligent man, who had died of pneumonia, some of the inner convolutions of the posterior lobes of the cerebrum were considerably atrophied, discolored yellow, and œdematous. These changes were more pronounced on the right side than on the left. The white fibres of the brain, by which this part of the brain is connected with the optic bulb, were penetrated by connective-tissue growths, and were in a state of amyloid degeneration. In the thalami optici, only the posterior nuclei were infiltrated by serum, very soft, and infiltrated with amyloid granules. In the gray substance surrounding the aqueduct of Sylvius, a similar pathological condition was observed. The rest of the brain was normal. The acoustic nerve was atrophic at certain points.

In a second case—a deaf-mute boy, fourteen years old, who died of tuberculous peritonitis—the same kind of changes were found in the brain, but in perhaps a less pronounced form. There was a widespread growth of connective tissue extending from the nerve-sheath, so that the nerve-elements were gradually crowded and finally destroyed.

Kuhn, who has reviewed the work of Luys, states (*loc. cit.*) that Hunter, in 1825, described a case of deafness in which extensive changes existed in the optic thalami.

Auditory Nerve, Sarcoma of.—The earliest manifestations of this affection of the auditory nerve may come on after taking cold from undue exposure. They may consist in anæsthesia of the face, of the nasal mucous membrane, with hypersecretion and bleeding of the nose, anæsthesia of the oral mucous membrane, defective vision, with increased secretion of tears, and ptosis on the side corresponding to the affected auditory nerve, with moderate headache and vertigo. The hearing and taste soon may become diminished, and in some cases the sense of smell is diminished. In the course of five or six months, the anæsthetic symptoms remaining unaltered, the vision may further diminish, and there may ensue diplopia, narrowing of the pupil, anæsthesia of the cornea, convergent strabismus, nystagmus, twitching of the mimic facial muscles, tonic spasm of the frontalis, intermittent vertigo, headache, unsteady gait, and atactic movements in the arm (Moos: *Arch. f. O. und Otol.*, Bd. iv. of the side corresponding to the seat of the tumor).

Post-mortem examination in such a case may reveal a round tumor, of unequal consistency, the size of a walnut, on the outer side of the porus acusticus internus, with its under surface toward the dura mater, its upper surface in connection with the peduncles of the cerebellum, compressing the pons and pushing the medulla toward the opposite side. The acoustic nerve may run within the growth, part of the way, and finally disappear in it. Further, in the widened porus acusticus internus, another smaller, rough tumor may be found. The vestibular nerve may be found uniformly thickened, the facial nerve thin and gray, as also may be the oculo-motor and fifth nerves. In the cervical and thoracic spinal cord there may exist excessive softening of the white substance, with hyperæmia of the gray substance, and gray spots in the posterior columns. Microscopic examination may show the tumor to be a very vascular spindle-celled sarcoma, in such a case. In the place of the lamina spiralis membranacea of the first, second, and third cochlear whorls, there may be a soft, yellow mass, composed of molecular, fatty detritus, cholesterin, and cells in fatty degeneration, supposed to be the remains of the epithelial structures in the organ of Corti.

The remnants of the lamina spiralis membranacea may show under the microscope a normal condition of the acoustic tract, for the most part, but at some points they may have lost their normal appearance, and exhibit strings of fat-molecules arranged in a line with their longitudinal fibres. The interdental cells may be in a state of fatty degeneration. Corti's membrane and the membrana basilaris may lose their fine longitudinal fibrillization, and instead display parallel, thread-like rows of extremely fine, closely packed granules. Corti's arches and their capitals may display a similar alteration. The epithelial cells in the region of the inner slope of Corti's organ may be enlarged and fatty, as also may be the large cell-epithelium of the sulcus spiralis internus, and the external epithelium of the ductus cochlearis. There may be no change in the vestibule.

In some instances the sarcoma may be attended by

great pain in the ear, lasting for many months before death. This is due to the extension of the disease from the internal ear, through the wall of the promontory to the middle ear, and even to the external auditory canal, as in a case of a man, sixty-six years of age, described by Burckhardt-Merian (*Archiv für Ohrenh.*, Bd. xiii., pp. 11-18, 1878). The pain in this case was so intense as to lead the patient to attempt suicide by hanging. The mastoid process became very tender and somewhat swollen, from external engorgement, as the sequel proved, since there was sclerosis of the bony walls and cells of the mastoid, and a reduction of the antrum to the size of a pea. A mastoid operation had been attempted. The maxillary articulation also became very tender, and the mouth was opened only about two centimetres, and with pain. There was no facial paralysis, and only slight vertigo, although the semicircular canals were implicated in the sarcomatous growth, as was shown after death; the facial nerve, however, escaping entirely the pathological process.

The sarcomatous growth may, as in this case, take its rise in the dura mater, on the posterior surface of the pyramid, and extend, after erosion of the bone, into the vestibule. The latter may become widened and filled with a moderately tough, yellowish-white new growth. The tumor, after originating from the dura mater, close to the point of entrance of the inferior petrosal sinus into the jugular fossa, may extend as a round cord-like structure through the greatly widened aquæductus cochleæ, beneath the floor of the internal auditory meatus. At this point it may divide into two branches, one branch, as large as a bean, extending into the widened and partly broken open vestibule, the semicircular canals may become embraced by the growth, and the promontory wall eroded through to the middle ear, and the granulations resulting therefrom may extend even into the tympanic portion of the Eustachian tube. The vestibular nerve may exhibit a circumscribed morbid enlargement in its course through the internal auditory canal, while the sacculus may show only a slight connection with the tumor.

The other branch of the tumor may extend in the form of a cord beneath the floor of the internal auditory meatus, to the adventitia of the internal carotid artery, with which it may be adherent, and from this point the tumor may form a thick, membranous covering, which finally surrounds the inner and upper portion of the partly necrosed, isolated cochlea, and finally send off into the dura mater a thin pedicle above the internal auditory meatus. The cochlea, at some points in the bony wall, may be thinned down to the membranous structures, and be found loosely placed in the pyramid. In the case of Burckhardt-Merian, alluded to, the tumor contained numerous spindle-shaped cells, and was denominated a fibro-sarcoma.

Sarcoma of the auditory nerve may occur in young subjects, as in the case of a girl seventeen years old, described by Dr. George T. Stevens (*Archives of Otology*, vol. viii., 171, 1879). Four years previous to her death there had begun diminution of mental activity, and the patient seemed to be "growing childish," *i.e.*, she preferred the society of very much younger children, and liked to play with dolls. In her fifteenth year she had fallen behind in her studies, and between thirteen and fourteen she had ceased to mature. Convergent squint began to replace a divergent squint she had had since she was six years old. There was now paralysis of the external rectus muscle of each eye. Finally, her movements became difficult and her words dragged. Two years before her death, unsteadiness of gait was observed. A year before her death deafness had been observed in the left ear. There was marked loss of muscular co-ordination in walking, but she could sew well.

Dr. Stevens diagnosed disease at the base of the brain, probably consisting in a tumor at the base of the left hemisphere. There now ensued, rapidly, great weakness, difficulty in walking and standing, and powerlessness of the right side. Gradually stupor, coma, difficulty of speech, and clouded intellect supervened, and in four weeks from the time of the diagnosis death ensued. In the last five days of life there was total inability to move the right arm or leg, but no cramps nor convulsions took place.

The autopsy revealed signs of recent and general meningitis, and upon turning out the brain the suspected tumor was found occupying a large portion of the fossa of the cerebellum, between the latter and the petrous part of the temporal bone. The tumor had encroached so much upon the fossa that the cerebellum was reduced on this side to half the size of the opposite side. The tumor proved to be a spindle-celled sarcoma in connection with the left acoustic nerve.

The cochlea may be invaded by round-cell sarcoma from the cerebellum (P. McBride: *Journal of Anatomy and Physiology*, vol. xiv., part ii., and *Archives of Otology*, vol. ix., p. 364, 1880). In the case referred to the round-cell sarcoma extended to the floor of the right internal auditory canal, and thence into parts of the bony wall of the cochlea. The patient was deaf, and affected with facial paralysis on the right side, the former symptom prevailing for one year, the latter for six months, before death. In the scala vestibuli of the cochlea there was found a coagulum occupying three-fourths of its lumen and the orifices of the modiolus. It was composed of a mesh of delicate, transparent fibres, and also contained in its network numerous lymphoid cells. The author believed this to be a croupous exudation, and attributes the deafness to a croupous inflammation, and not to pressure of the tumor upon the nerve-trunk, since the paralysis set in so late. The periosteum of the cochlear convolutions, as well as Reissner's membrane, was thickened. The vessels of the osseous and soft tissues were dilated. The cochlear wall showed an infiltration of small round cells, similar to those found in the sarcomatous tumor. Corti's organ was normal in appearance, and there was no exudation, either in the vestibule or in the semicircular canals. In a second case, by the same author, the right labyrinth of a patient who had died of acute rheumatism, and who, while taking salicylic acid, had become deaf (see Permanent Alterations in Hearing produced by the Use of Quinine and Salicylic Acid), was examined, and one of the bony semicircular canals revealed, on section, an angular instead of a round lumen, and its membranous canal was surrounded by connective tissue. This was considered metamorphosed myxomatous tissue, dating from fœtal life.

Adenoma of the petrous portion of the temporal bone may involve the internal ear as well as the middle ear, and even the external auditory canal, as shown in a case reported by Samuel Sexton, M.D., of New York (*New York Med. Journal*, December 13, 1884). In this most interesting and extraordinary case the patient, a man, who succumbed to the disease at the age of forty-five, presented a remarkable train of nervous symptoms for many years preceding the strictly aural symptoms, which latter set in between the patient's twenty-fifth and his twenty-seventh years. In early life he had St. Vitus' dance, and from the age of fourteen to twenty-four he had endured a laborious and exposed life as a sailor, was often struck on the head, had dizzy spells, and falls. At twenty-five years of age he became suddenly ill "with some head disease," when it was noticed that the right side of his face became paralyzed, his speech became imperfect, and deglutition became difficult. Two years later the hearing failed, and tinnitus aurium was established in the right ear, in consequence, as it was then thought, of a severe cold in his head. During the two succeeding years vertiginous attacks became more frequent and more severe, being characterized by dizziness, pallor, coldness of the body, and profuse sweating; in fact, we have here a neuropathic form of Ménière's disease. There was stupor, and even unconsciousness, lasting for an hour or more, followed by prostration, dizziness, and intellectual confusion, which symptoms could be induced by over-work or excitement. A heavy feeling in the head, increased mental depression, and nervousness ensued, and the deafness in the right ear was marked. In the next four years the condition varied; sometimes the patient could work,

and again he was unable to. At the end of this period, in the patient's thirty-fourth year, there was another intercurrent attack of catarrhal inflammation of the middle ear, with great pain in the organ. This was followed by a discharge. A severe cough set in, showing some symptoms of ear-cough, and the pain in his head became constant. He could not sit up without experiencing vertigo, and in walking or standing he was obliged to hold on to something for support, and upon one occasion he fell in the street and became unconscious, which latter symptom shows that the vertigo was not in connection with ordinary Ménière's disease, which is not attended by unconsciousness. With similar symptoms, in varying intensity, five more years elapse, when he presented himself to Dr. Sexton on May 5, 1875. The patient was of medium stature, dark skinned, and weighed at this time one hundred and thirty pounds. He denied having had syphilis. His cough (ear-cough ?) was troublesome, and the introduction of a speculum or a probe into the ear caused severe paroxysms of coughing. He was very nervous and had muscular twitchings in the face. He was very somnolent, weak, unsteady in his gait, and could not swallow food without taking a mouthful of water. Paralysis of the right side of face was marked, and he felt a weakening of the entire right side of the body. There were constant pains in the head. The osseous fundus of the right auditory canal was nearly occluded by a bulging of the posterior-superior wall, in the form of a sacculated, purplish mass, which did not bleed easily from touching, but which bled freely on scarification. There was not a constant discharge from the ear. The membrana tympani was intact, though thick and parchment-like in appearance. Above and behind the auricle, just beneath the squamo-parietal suture, there was a soft, fluctuating tumor slightly elevating the scalp, not much discolored, not tender to the touch, and about 2.50 ctm. in diameter. This sac contained a sero-sanguinolent fluid, and a mass of friable structure, the latter extending downward and inward to the bone. Deep pulsation was felt within the incised tumor of the scalp, and the existence of a deep intracranial tumor was diagnosticated. At this time there was nothing abnormal in the eyes. Subsequently, with a worse condition of the head-symptoms, the vision of the right eye failed. In the course of one year, with increasing somnolence, loss of power in the right leg, weakness, attacks of prolonged vomiting, coldness of the right hand, the patient grew worse. He could only sleep when propped up; albumen was found in the urine, but there were no casts; feet and legs were swollen, and vomiting was frequent, without nausea. Constipation was now succeeded by diarrhœa, there was rapid loss of vision, there was cough with offensive sputa, and the patient sank. After a short rally the patient died slowly and easily, retaining his intellectual faculties to the last.

The autopsy, made the day after death, revealed considerable congestion of the meninges, but no evidence of recent inflammation. The tumor, yet to be described, had pressed a hollow into the cerebellum. The meninges were not very adherent to the tumor, and there was no pus anywhere within the skull. Internally the tumor occupied the front and back surfaces of the pyramidal part of the temporal bone, and was covered by the dura mater. Its size equalled that of a turkey's egg. The whole of the petrous bone was involved in the tumor, the apex alone remaining free, at the orifice of which could be seen the internal carotid artery, losing itself finally in the tumor. The centre of the tumor had eroded the petrous portion of the bone. On removing the tumor from its bed it brought away the whole petrous bone from behind the tympanum, inward to within half an inch of the apex.

Externally, the tumor had destroyed and occupied the place of the anterior half of the squamous plate of the temporal bone, extending forward to the articulation of the great wing of the sphenoid; anteriorly and inferiorly, to the posterior wall of the meatus externus; superiorly, to the level of the posterior-superior angle of the great wing of the sphenoid; posteriorly, to a vertical line about one inch behind the apex of the mastoid process; downward, into the mastoid process. Within the space thus mapped out the external surface of the tumor was exposed. At the edges of the opening thus made in the squamous plate, the dura mater was very adherent.

The microscope revealed the tumor to be a destructive cylindrical-celled adenoma. Parts of the tumor were angiomatous. It was supposed by Dr. W. H. Welch, who made the microscopic examination, that the tumor probably originated either from the middle or internal ear, as in these parts are found cylindrical epithelial cells. In this connection Dr. Welch also suggests Cohnheim's hypothesis as to the origin of tumors from misplaced or superabundant embryonic cells.

Concretions of Phosphate of Lime in the Auditory Nerve.—Boettcher asserts the frequent occurrence of concretions of phosphate of lime in the periosteum of the internal auditory canal, most frequently at the fundus. They are found in the middle-aged as well as in the very old. They consist in homogeneous, or concentrically laminated bodies of globular, oval, or club shape, and of a whitish-yellow color, and in the fibrous tissue of the periosteum they are surrounded by connective tissue.

Moos, too, has not uncommonly found such concretions. In a deaf-mute they were found in the periosteum of the porus acusticus internus, in the neurilemma of the acusticus, and on the membranous sacculi of both vestibules (Steinbrügge's Review, *Archives of Otology*, vol. viii., 1879, p. 96). In a woman, forty-four years old, who had been very deaf for some time, Moos found, post mortem, concretions of phosphate of lime in the trunk of both auditory nerves. There was also in this case great tinnitus aurium, and congestion of the manubrial plexus. Numerous concretions of phosphate of lime were also found in the lamina spiralis membranacea of the left cochlea. It was supposed that the subjective auditory sensations were materially increased by the development of concretions of phosphate of lime in the body of the acoustic nerve, since these bodies must be regarded as mechanically tetanizing media, continuously acting.

Moos and Steinbrügge also found concretions of phosphate of lime in the auditory nerves of a deaf-mute, with nerve-atrophy (*Archives of Otol.*, vol. xi., p. 240, 1882).

Fester has described three cases of psammoma or fibro-psammoma of the brain, two of which implicated the acoustic and facial nerves. In one case the acoustic nerve was atrophic, in a state of fatty degeneration, and contained concretions in the thickened neurilemma. In a second case, the nerve itself showed such deposits between the still remaining, thin and atrophic fibres. The corpuscles could be traced into the cochlea and semicircular canals, thus permitting conclusions as to the peripheral commencement of the neoplasm, with centripetal development.

Huguenin demonstrated that in brain tumors the resulting descending optic neuritis is due to a chronic inflammation of the sheath of the nerve. In the same way, in brain tumors, there may occur a neuritis olfactoria or a neuritis auditoria. Disturbances of sight, hearing, and smell, do not aid us in determining the seat of the brain tumor, because almost all cerebral tumors cause a chronic inflammation at base of brain, which produces a neuritis descendens in the nerves encroached upon, in which, according to its intensity, it brings about atrophy.

Charles H. Burnett.

AUGUSTA. (For detailed explanation of the accompanying chart and suggestions as to the best method of using it, see Climate.) The city of Augusta, Ga., lies on the western bank of the Savannah River, at a point two hundred and thirty-one miles distant from its mouth. The town, which in 1870 had a population of 15,389, increased ten years later (1880) to 21,891, is one of the chief commercial centres of the South; and both on account of its agreeable climate, its well-chosen location, and the tasteful manner in which its streets are laid out, possesses many attractions as a place of residence. Augusta is but seventeen miles distant from the now famous health re-

sort of Aiken, S. C., a description of which latter place is to be found in the earlier pages of this HANDBOOK; and there is, very naturally, a great similarity existing between the climates of the two places. From its lower elevation above sea-level, and still more from its immediate proximity to the Savannah River, and the more alluvial nature of the soil, the climate of the town of Augusta itself differs considerably from that of Aiken in one important respect, viz.: in that of humidity. As shown by the figures representing Relative Humidity, which are given in the meteorological charts accompanying the accounts of both places in this HANDBOOK, neither Aiken nor Augusta possesses an excessively dry, nor yet a very dry climate; but, following the classification of Vivenot, these figures may be interpreted as indicating for Aiken the possession of a "*moderately* dry," and for Augusta, the possession of a "*moderately* moist" climate.

To Dr. Henry F. Campbell, a well-known physician resident at Augusta, the writer is greatly indebted for supplying him with much valuable information concerning the climate of the town, and concerning its desirability as a place of residence for invalids. In two letters received from this gentleman, and bearing date respectively January 1 and 4, 1885, the following description of the soil of Augusta is given: "The soil, on the level plain of Augusta, is alluvial, mica being largely mixed with the aluminous elements, while the highlands and hills in the vicinity are principally formed of sand, with a rocky or slaty substratum." (Letter of January 1st.) "But," the Doctor goes on to say, in a letter written a few days later (January 4th), "though our soil is alluvial, over a hundred years of thorough cultivation has eliminated all morbific elements and established thorough drainage in all the surrounding country." Between the climate of the highlands and hills in the vicinity of Augusta and the climate of Aiken, a much smaller difference doubtless exists in the matter of humidity than does exist between the climate of Aiken and that of Augusta itself; and the reputation of these highlands as health resorts has been established for many years past. In the matters of soil and vegetation these places are almost identical with Aiken, and, although the writer possesses no meteorological statistics to prove that such is the case, it is, nevertheless, most reasonable to infer that like causes must necessarily produce like effects, and that these sandy and pine-growing regions closely resemble the neighboring town of Aiken in point of humidity, as they certainly do in respect to all other climatological factors. Among such resorts the best known are the Pine Heights (station Grovetown, on the Georgia Railroad), about fifteen or twenty miles west of Augusta, and the village of Summerville, or the "Sand Hills," only three miles distant from the town, and connected with the latter by a line of horse-cars. This settlement of Summerville is a very favorite place of residence for the wealthier inhabitants of Augusta, many of whom have their villas built upon its sandy soil. Concerning this spot, Dr. Campbell says: "The Sand Hills, three miles west of Augusta, . . . had, as early as the beginning of the present century, acquired the name of 'Mount Salubrity' on account of its mild and healthful climate and its conditions so generally acknowledged to be favorable to the consumptive." The Pine Heights, above alluded to, probably possess a climate more nearly identical with that of Aiken than is the climate of the Sand Hills, for the location of the latter place, within three miles of the Savannah River, as well as the immediate proximity of the alluvial plain from which the hills arise, must necessarily tend to produce greater humidity of atmosphere than would be found in a place lying upon a moderately high and an extensive sandy plateau, and at a considerable distance from any large body of water. Such we know to be the location of Aiken; such also, judging from its geographical position, is probably the location of the Pine Heights, which claim to possess an altitude above sea-level and a climate corresponding to those of the former place.

The city of Augusta possesses four hotels, and Dr. Campbell states in one of his letters that "a large number of comfortable boarding-houses exist in the town itself, while excellent board can also be obtained at the Sand Hills, at Pine Heights, and at other localities near the city." No sanitarium, or hotel specially fitted for the accommodation of invalids, seems to exist, as yet, either within the town, or at any of the neighboring places, although the project of establishing such a hotel at the Sand Hills was set on foot some two years ago.

Concerning the water-supply and the drainage of Augusta, concerning the general healthfulness of the town, the facilities presented for out-of-door exercise, and the existence of opportunities for the education of the children of families desiring to make the city or its immediate neighborhood a place of more or less permanent residence, the letters of Dr. Campbell supply the following items of useful information:—

"The water-supply of this place is abundant and excellent—source elevated, and water by pipes in all dwellings. The drainage and sewerage are well devised and well constructed, and are being largely extended to meet the requirements of the city. . . . The diseases of this locality are usually a mild and manageable type of intermittents—the continued or typhoidal forms of fever are somewhat rare, never prevailing epidemically. As a general thing the exanthematous fevers are mild in their progress, and not largely fatal. . . . Yellow fever, occasionally epidemic on our coast, has twice only been transported to Augusta—in 1839 and 1854—both years in August and September. . . . Rheumatism, cardiac affections, renal affections, and, I think, cutaneous diseases, are much less frequent here than in most of the Northern and Eastern States. . . . As to facilities for out-door exercise:—The roads around Augusta are numerous and well kept, and pass through regions diversified by pine and oak forests, and broad cotton and corn fields. Our streets are generally level, broad, and well paved, rendering walking attractive and practicable at some portion of every day in the year. Hacks, horses, and street-cars in the city and to the Sand Hills, afford abundant and cheap facilities for riding and transportation. In regard to schools and facilities of education, I can say that our public and private schools are well conducted and systematically managed, and are attended by the children of our best citizens. Sojourners here would not necessarily have to interrupt the studies of their children during their stay either in the winter or summer. The Richmond Academy for Boys is one of the most venerable, and at this time one of the best conducted institutions in the United States."

In one respect Augusta excels most of the health resorts to be found within the borders of the Southern States, viz., in the opportunity offered to business men, suffering from impaired health, of recovering their strength and health by prolonged residence at or near the town without incurring the necessity of abandoning their source of livelihood and the business habits to which they have always been accustomed.

"Active business men who, on account of impaired health, must seek a milder climate than that of the Eastern and Northern States, will find themselves in a business atmosphere congenial to their habits and tastes, and among business men, a large number of whom have become permanent residents on account of their formerly impaired health, or that of their families, in a more rigorous climate." (Letter of Dr. Campbell, January 1, 1885.)

In this connection it is important to remark that the same dying out of an hereditary tendency to consumption which has been observed among the descendants of persons who have taken up their residence upon the Island of Madeira on account of their own impairment in health, has likewise been found to prevail among the children of such invalided parents who have made choice of Augusta as a home for themselves and for their families.

It is for the alleviation or for the cure of cases of pulmonary phthisis that the climate of Augusta is chiefly noted; but the mildness of its winter temperature and its other features (deducible from the figures of the accompanying chart, and from a comparison of these figures with those standing in the corresponding columns of the charts for other resorts and for other towns which are

Climate of Augusta, Ga.—Latitude 33° 28′ *N., Longitude* 81° 54′ *W.—Period of Observations: January* 1, 1872, *to December* 31, 1883. *Elevation of Place of Observation above the Sea-level,* 167 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	42.0	54.9	46.4	47.7	56.5	40.9	57.0	39.7	79.0	64.0	31.0	15.0	21	24
February	44.3	58.9	49.2	50.8	56.7	46.0	63.0	43.6	82.0	67.0	34.3	22.0	19	20
March	48.9	65.3	54.3	56.1	61.3	50.7	69.1	47.8	89.3	76.0	37.3	22.0	22	24
April	57.9	72.6	61.3	63.9	67.4	60.6	74.5	54.6	90.0	81.0	45.0	31.0	19	21
May	67.2	81.0	69.2	72.4	75.7	69.8	83.2	63.0	100.0	89.0	58.3	42.0	18	23
June	74.7	86.7	76.1	79.1	81.3	78.0	88.2	69.3	101.8	94.0	68.0	57.0	20	20
July	78.1	89.2	79.1	82.1	84.8	78.6	92.5	74.0	105.0	94.0	72.0	62.0	25	26
August	75.2	86.6	77.1	79.6	83.7	76.1	89.5	72.2	105.0	91.0	70.0	61.0	29	27
September	69.5	82.6	72.2	74.7	79.4	73.0	84.9	66.7	97.0	90.4	64.4	48.0	24	15
October	57.8	73.5	62.0	64.4	70.6	59.4	76.6	58.7	92.0	81.0	49.0	29.0	19	24
November	47.5	62.0	51.7	53.7	57.4	47.5	64.5	45.8	84.0	75.0	33.0	24.0	21	19
December	41.7	55.6	46.0	47.7	53.9	38.5	59.0	40.4	77.0	65.0	31.8	7.0	23	24
Spring	......	......	......	64.1	68.1	62.7	......	......	......	......	......	......	......	......
Summer	......	......	......	80.2	82.2	79.0	......	......	......	......	......	......	......	......
Autumn	......	......	......	64.2	68.9	61.2	......	......	......	......	......	......	......	......
Winter	......	......	......	48.7	55.1	45.2	......	......	......	......	......	......	......	......
Year	......	......	......	64.3	65.8	61.8	......	......	......	......	......	......	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of clear and fair days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind.
		Per cent.				Inches.	From	Miles.*
January	64.0	74.3	9.6	10.6	20.2	4.64	N.W.	3.5
February	60.0	68.4	11.8	7.8	19.6	3.88	N.W.	4.3
March	67.3	65.1	10.1	12.2	22.3	5.86	N.W.	4.9
April	59.0	64.8	11.6	10.8	22.4	4.64	N.W.	4.5
May	58.0	64.4	12.8	12.6	25.4	3.09	S.E.	4.0
June	44.8	68.1	15.3	8.4	23.7	4.25	S.	3.9
July	43.0	68.7	14.4	10.4	24.8	4.46	S.E.	3.3
August	44.0	73.3	15.2	8.1	23.3	4.78	N.E.	3.1
September	49.0	72.4	12.5	10.3	22.8	3.97	N.E.	3.4
October	63.0	71.9	10.1	14.2	24.3	2.23	N.E.	3.6
November	60.0	72.3	10.1	10.4	20.5	4.29	N.W.	3.7
December	70.0	73.4	11.3	10.2	21.5	4.06	N.W.	3.3
Spring	78.0	64.8	34.5	35.6	70.1	13.59	N.W.	4.5
Summer	48.0	70.0	44.9	26.9	71.8	13.49	S.	3.4
Autumn	73.0	72.2	32.7	34.9	67.6	10.49	N.E.	3.6
Winter	75.0	72.0	32.7	28.6	61.3	12.58	N.W.	3.7
Year	98.0	69.8	144.8	126.0	270.8	50.15	N.W.	3.8

* Per hour.

given in this HANDBOOK), will indicate the suitability of the climate as a powerful factor in the alleviation or cure of several other forms of disease and in the removal of various other dyscrasiæ.

In conclusion, the following figures, deduced by calculation from the statistics of the United States Census for 1880, and showing the proportion of deaths attributed to consumption which occurred in every 10,000 of population during the census year, are herewith presented to the reader: Georgia, 11.14; New York, 25.29; Massachusetts, 29.20; Vermont, 24.46; New Hampshire, 24.95; Maine, 28.18; Rhode Island, 24.98; New Jersey, 23.25; Connecticut, 22.67; Pennsylvania, 18.85.

Huntington Richards.

AUGUSTUSBAD, near Dresden, Saxony, contains six chalybeate springs, slightly impregnated with CO_2. Altitude, 220 metres (720 feet). The "Stollen" spring contains the greatest amount of iron, 0.31 parts in 1,000. The air of Augustusbad is balsamic and pleasant in the summer months. *H. F.*

AULUS, situated in the Puy de Dome, between high mountain cliffs, 33 kilometres (21 miles) distant from St. Girons (latitude, 42° 59′ N.), contains one spring and bath-house. Temperature of the water, 20° C. (68° F.). According to Filhol, the percentage of solids (chiefly sulphate of calcium, 17.6, and sulphate of magnesia, 2.6) is 22 in 1,000 parts. There are also traces of hydrogen chloride HCl, carbonic acid, arsenic, copper, tellurium, and chromium. The value of a short course of this water in the treatment of syphilitic affections has been asserted on good authority. *H. F.*

AURICLE, ANATOMY AND PHYSIOLOGY OF. The auricle, or pinna, pyriform in shape, occupies a position between two imaginary lines running horizontally, the upper one touching the eyebrows, the lower one the tip of the nose. The angle that it forms with the lateral part of the head toward the occiput, is subject to great variations in different individuals. It is composed of cartilage of the yellow or reticular variety, one to two millimetres in thickness, and is covered by perichondrium. The cartilage does not enter into the construction of the lobule; it is also deficient between the tragus and spina helicis, the space being filled up by dense connective tissue. The integument covering the auricle is much more closely adherent to the perichondrium on the anterior or outer surface of the pinna than on the posterior or convex surface, owing to the greater development of the subcutaneous connective tissue. The lobule, formed by a reduplication of the integument, contains fat and dense connective tissue. Occasionally the cartilage from the auricle is continued into the lobule, so that the operation of piercing the ears may give rise to chondritis. Sebaceous glands, 0.5 to 2 mm. in diameter, scattered over the auricle, are found in the greatest number in the concha. The surface of the auricle is covered with very fine, soft hairs. Occasionally they are highly developed at the tragus and around the meatus in the region of the helix and antitragus. Sudoriferous glands are very numerous on the posterior surface of the pinna.

The outer or concave surface of the auricle presents numerous depressions and elevations. The outer edge (*h*), curved forward and outward, called the helix, extends from the spina (crista) helicis (*sh*) above the external auditory meatus, along the margin of the auricle, upward

and backward, to the posterior margin of the lobule. A second elevation (*ah*), the antihelix, running in a parallel direction with the posterior portion of the helix, commences with two (branching crura) (*cf*) crura furcata above the crista helicis, and terminates in a cartilaginous protuberance (*at*), the antitragus. Between these two ridges or elevations is found a depression (*fs*), the fossa scaphoidea, or fossa of the helix, or fossa navicularis. The fossa intercruralis (*fi*) is the name given to the space between the two crura of the antihelix ; it is also called the fossa triangularis or fossa of the antihelix. The tragus (*t*) is the prominent nipple-shaped projection opposite the antitragus and in front of the external auditory meatus, and partly covering the orifice (*im*). The incisura intertragica is the notch (*i*) between the tragus and antitragus. The concha (*c*) is the cup-shaped depression of the auricle. The lobulus (*l*), the lower extremity of the auricle, is subject to great variations as regards shape and size.

There are two sets of muscles, peculiar to the auricle, the extrinsic and intrinsic. Those of the first group are the, 1, *attollens auriculam*, which draws the auricle upward, a fan-shaped muscle, arising from the epicranial aponeurosis, with fibres converging downward, and attached to the upper and convex surface of the auricle ; 2, *attrahens auriculam*, which draws the auricle a little forward and upward, also arises from the epicranial aponeurosis above the zygoma and in front of the auricle, and is attached to the spina helicis ; 3, *retrahens auriculam* pulls the auricle backward : it arises from the mastoid process, and its fibres are inserted into the posterior and convex surface of the concha. The intrinsic muscles are peculiar to the auricle itself. They are pale, extremely thin, and rest upon the cartilage ; they are inserted into the perichondrium. These muscles, when they act, are supposed to alter the shape of the auricle to a slight extent. They are the *tragicus, antitragicus, helicis major, and helicis minor* on the anterior or concave surface ; the *transversus* and *obliquus auriculæ* on the posterior or convex surface.

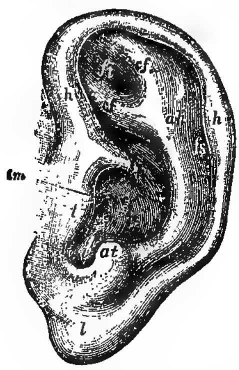


FIG. 356.—Auricle. (After Urbantschitsch.) — *ah*, antihelix; *at*, antitragus; *c*, concha (fossa conchæ); *cf*, crura furcata ; *fi*, fossa intercruralis ; *fs*, fossa scaphoidea ; *h*, helix ; *i*, incisura intertragica ; *im*, introitus meatus audit. extern.; *l*, lobulus ; *sh*, spina (crista) helicis ; *t*, tragus.

A muscle, called the *musculus incisuræ Santorini*, in the auditory canal, is sometimes, though rarely, described. According to Hyrtl, it arises from the anterior circumference of the external meatus ; its direction is downward and forward, and it is inserted into the inferior border of the tragus. It serves to draw the tragus forward, and thus enlarge the space of the concha.

The ligaments, as the muscles, are divided into the extrinsic and intrinsic. The extrinsic ligaments are the anterior, extending from the spina helicis to the root of the zygoma, and the posterior, arising from the outer surface of the mastoid process, and inserted into the posterior surface of the concha. The intrinsic are also two in number : one passing from the tragus to the spina helicis ; the other connecting the concha and the lower extremity of the antihelix.

The anterior surface of the auricle is supplied by the arteriæ auriculares anteriores, branches of the arteria temporalis superficialis ; the posterior surface, by a branch of the arteria auricularis posterior from the arteria carotidea externa. The arteria occipitalis also sends an auricular branch.

The veins accompany the corresponding arteries.

The nervous supply is derived from the nervus auricularis magnus of the cervical plexus ; the nervus auricularis posterior from the nervus facialis ; an auricular branch (Arnold's) from the nervus vagus ; the nervus auriculo-temporalis from the nervus inframaxillaris. The posterior or inner surface of the auricle is well supplied with nerves, while very few are distributed on the anterior or external surface and lobule.

The auricle is richly supplied with lymphatics.

Different views are held as to the function of the auricle in the reception and reflection of the sound-waves. Some authors assert that the depressions on the concave surface are very important, while others maintain that the auricle is simply an appendage. Politzer has made a series of experiments in individuals whose hearing was affected, because "in such persons, the hearing-distance for continuous sounds is much more sharply defined than in persons whose ears are normal." Having fixed the head of the patient, he ascertained the hearing-distance first with the metronome, which is then placed somewhat within the boundary of the hearing-distance. He found that when the concha was covered with a piece of stiff paper, leaving, however, the orifice free, that the patient was unable to hear the sound of the instrument. By covering the other depressions on the auricle, no effect was noticed on the hearing-distance. The size of the auricle and the angle it forms with the side of the head undoubtedly have some influence on the hearing-distance, for with persons of normal hearing, as well as with those who are deaf, the hearing-distance is increased when the auricle is bent forward by the hand. Politzer considers "the tragus of great importance for the reflection of the waves of sound which strike the auricle." A hollow space, opposite the concha and the orifice of the external meatus, is formed by means of the tragus. The waves of sound are reflected here by the auricle (concha) and thrown into the auditory canal. Burnett divides the sounds of nature, composed of a large number of partial tones, as the rustling of leaves, roar of the surf, etc., into deep, intermediate, and high partial tones. The normal ear perceives these partial tones as a whole, not isolating them. This is explained by the fact that "certain parts of the auricle resound best to the high partial tones, while other portions of it resound best to the intermediate and low partial tones, thus insuring the complete reception by the auditory nerve of all the partial tones which compose any given sound falling on the auricle." According to that author, the region of the helix and its fossa resound to the deeper notes, the antihelix and its fossa to the intermediate, and the concha resounds best to the high partial tones. Küpper adopts Darwin's theory, and looks upon the auricle simply as an appendage, one of the organs that evolution has made useless in man ; while Mach, whose views otherwise agree with those of Küpper, considers the auricle a resonator for high tones, such as the rustling of the leaves. This function, highly developed in animals, exists only to a slight extent in man. Roosa believes "that the auricle is only a rudimentary organ and not of value in hearing, except under exceptional circumstances." Dr. E. Mendel has performed some experiments to determine the difference in the temperature of the rectum and that of the external ear, both in health and disease. Normally, the temperature of the rectum is .02° C. higher than that of the external auditory canal. Chloral given in a dose sufficient to produce sleep, will reduce the temperature from .04° to 1° C. in the external auditory canal. Morphia also causes a fall of temperature of from .1° to .45° C.

Gorham Bacon.

AURICLE, CONGENITAL DEFECTS, DISEASES, AND INJURIES OF. CONGENITAL DEFECTS.—These may consist in arrested development or in excessive development.

Arrested development includes (*a*) absence of the whole or parts of the organ, (*b*) microtia, and congenital fistula. Excessive development consists in (*a*) plurality of the organ or of any of its parts, (*b*) abnormal enlargement, (*c*) polyotia, (*d*) reduplication. Besides these anomalies the organ may occupy an abnormal position, or present deformities due to defects in the cartilage ; thus the superior border of the helix may be absent, the unsupported integument lapping over anteriorly in consequence,

or the auricle may be convoluted in shape, resembling a rosebud in form.

These defects are for the most part due to either excessive or imperfect development in the closure of the first branchial cleft, and are, moreover, often associated with absence of the external auditory canal, or with some defect of this part of the organ. Occasionally, either a dimple or papilla marks the seat of the closure of the first branchial cleft; the former usually occurs on the anterior sweep of the helix, and leads down into a sinus; the latter just in front of the tragus; but they are sometimes found in other localities on or about the auricle. Fig. 357 is from a photograph of a congenital fistula of the ear. Any of these deformities may occur on one or both sides, and they are often the cause of total deafness. Fig. 358 is an example of congenital deformity of the auricle, with absence of the meatus, and Fig. 359 represents a convoluted auricle which, when unrolled showed the opening of a *fistula auris congenita* on the outer aspect of the helix, near the anterior-superior border, and atresia of the meatus.

Fig. 357.—Congenital Fistula of the Ear.

Treatment. — Otoplasty is of service in correcting some of these defects, but its usefulness has a limited range; it is, however, resorted to sometimes where the deformity is marked, and it may be said that plastic operations in this region do well in respect to the healing process. When excision of excessively developed parts of the auricle is performed, a small portion of cartilage is frequently found beneath the skin. Rarely operative procedures have been undertaken with a view to open a way down to the middle ear in cases of atresia, stenosis, or complete absence of the external auditory canal; but they never have been attended with an encouraging degree of success.

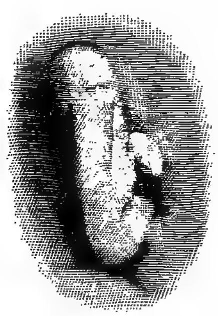


Fig. 358.—Congenital Deformity of the Auricle, with Absence of the Meatus.

Cutaneous Diseases of the Auricle.—The following cutaneous affections of the auricle (sometimes extending into the external auditory canal) are liable to fall under the observation of the otologist, namely: (*a*) callosities; (*b*) comedo; (*c*) dermatitis; (*d*) eczema; (*e*) erysipelas; (*f*) erythema; (*g*) furuncle; (*h*) gangrene; (*i*) herpes zoster; (*j*) hydroa; (*k*) ichthyosis; (*l*) intertrigo; (*m*) keloid; (*n*) leprosy; (*o*) lupus; (*p*) molluscum fibrosum; (*q*) nævus; (*r*) pemphigus gangrenosus; (*s*) pernio; (*t*) phagedæna; (*u*) phlegmon; (*v*) syphilodermata; (*w*) tophi; (*x*) trichophytosis, and (*y*) ulcer.

The skin troubles of greatest interest to the otologist are those which cause deafness by their extension from the auricle to the lining of the external auditory canal, and frequently by continuity of tissue even to the outer covering of the drum-head itself. The most important in respect to this are eczema and erysipelas, which will be considered in their proper places. The most common of cutaneous affections which will demand our attention are as follows:

Fig. 359.—Convoluted Auricle, with Congenital Fistula Auris.

Comedo.—Comedo consists in the retention of hardened sebum in the sebaceous follicles, and is commonly found in the concha of ears which are the seat of chronic inflammatory processes. The dirt-begrimed plugs thus formed are often very unsightly, and they even invade the lobule and contiguous parts. Sometimes the sac containing them becomes irritated, and a small tumor forms. Since this impaction is most frequently met with during the period of adolescence, the necessity for looking to the state of the general health is suggested. The local treatment consists in pressing out the hardened sebum between the nails, or a watch-key may be employed, the opening of which, having been made round and smooth, is pressed down upon the skin, so that the plug can escape into the tube.

Eczema.—This non-contagious cutaneous trouble is the most common to which the auricle is liable. It is of constitutional origin, and in many instances seems to have a predilection for this region. Its varieties are similar wherever it manifests itself, and since their description will be found under *Eczema*, it will be necessary in this connection to consider the disease only as modified by the local conditions and its effect on hearing. At our aural clinics, where the affection is mostly seen as occurring among the badly-cared-for, one is struck by the fact that in its acute form it is found mostly in children, three-fourths of whom are females, and that, moreover, its outbreak and exacerbations seem to be excited by nasal catarrh and difficult dentition. The chronic form of the disease, on the contrary, is usually observed in elderly persons. In 99 consecutive cases of eczema of the ear in which full notes were taken by the writer, there were 5 cases between 1 and 18 months of age; 8 cases were 18 months of age; 8 were between 18 and 30 months; 6 were from 3 to 6 years of age; 8 were 6 years old; 9 were 7 to 14; 19 were 18 to 30; 12 were 30 to 40; 14 were 40 to 50; 6 were 50 to 60; 4 were 60 to 70. Of the whole number 69 were females and 30 were males; and there were 40 under 10 years of age, namely, 25 females and 15 males. It will thus be seen that eczema occurs more than twice as frequently in females as in males; this is specially notable as regards young children. Females with menstrual difficulties are, it is believed, particularly obnoxious to eczema. In my own experience the left ear is more frequently affected than the right ear. Among the exciting causes of eczema, besides the diathetic and sympathetic, are acute and chronic purulent inflammation of the middle ear, and wounds and injuries of the auricle. Eczema intertrigo, an invasion of the fissure formed by the junction of the auricle with the mastoid region, is a common occurrence.

Deafness is sometimes temporarily produced by the closure of the meatus from the swelling in acute cases; defects in the hearing, however, more frequently arise from an invasion of the deeper parts in chronic cases where the dermic layer of the external auditory canal and membrana tympani are affected. Stenosis of the canal, from infiltration and thickening of its lining, is not infrequent in such cases. The treatment of eczema of the ear requires special care when the deeper parts of the organ are involved; for which see External Auditory Canal. It is important not to confound the thickening of the auricle and occasional dermatitis of this organ with the "erysipelas" of the laity.

Erysipelas.—During the progress of facial erysipelas the auricle is exceedingly liable to be attacked, and, after once becoming affected, this organ is afterward subject to frequent returns of the trouble. Like eczema, it may invade the deeper parts of the ear, and cause deafness, which, in some degree, is often permanent. Erysipelas is much more liable than eczema to temporarily interfere with hearing, in consequence of swelling of the exterior parts. This inflammatory affection, so far as my own observation goes, seldom affects children. In the treatment of erysipelas I have found the tincture of aconite of much service, especially when given during the pyrexia. Locally, the tincture of belladonna, half a drachm to the ounce of water, or a weak ointment of the same drug, is a good remedy. The latter may be employed when the

external auditory canal is affected. For the management of stenosis of the canal from infiltration in chronic eczema, see External Auditory Canal.

Pernio.—Frost-bite of the auricle frequently occurs in persons exposed to severe cold, as sailors, soldiers, woodmen, and others; some individuals, especially susceptible, experience repeated attacks. The popular treatment is well suited to the trouble; it consists in the application of snow or ice-cold water to the parts before entering a warm room, which prevents too sudden reaction. Chronic dermatitis, often a sequel to this affection, as well as to eczema and erysipelas of the auricle, is afterward liable to exacerbations during cold weather.

Tubercular Syphilide.—The only allusion to the invasion of the auricle by the tubercular syphilide that I find in the exhaustive treatise of Bumstead and Taylor is, that in two cases observed by the authors, where extensive eruptions occurred on the body and face, the lobules of the ears were destroyed.

FIG. 360.—Tubercular Syphilide of the Auricle.

It would seem that the tubercular syphilide is a tertiary lesion met with late in syphilis, that it is not liable to ulcerate, and that the loss of tissue, when present, is due to interstitial absorption. It is more liable to occur in cases that have not been thoroughly treated at the onset. It usually has a chronic course, and is without pain, heat, or itching. The tubercles may be limited in num ber and confined to a single region. In the work above cited, the tu bercles are said to "begin as deep-red spots, which slowly increase in size and thickness until, when fully developed, they have a diameter of from one-half to one inch." (See Fig. 360.) In my own experience the disease seems disposed to confine itself to the anterior portion of the pinna.

Atrophy follows this eruption; but, unless tubercles have been permitted to remain long without treatment, cicatrices, if present, may not leave any marked deformity. An example of atrophy, due to this lesion, is shown in Fig. 361.

Should ulceration occur in any portion of the eruption, which happens sometimes, the thickness of the crust will be increased—its color becoming greenish-black, its surface rough, and the resulting cicatrization leaving unsightly scars.

It appears, according to Bumstead and Taylor, that the course of the syphilitic eruption is not infrequently interrupted, or even permanently arrested, by some acute disease. Numerous instances of this have been reported, the influence of erysipelas being most frequently observed, according to French authorities. A case which occurred in my own practice seemed to possess much interest for the syphilologist in consequence of the apparent influence of the intercurrent invasion of eczema during its course. *After the dropping off of the scabs had occurred, it was found that there had been scarcely any loss of tissue underneath.*

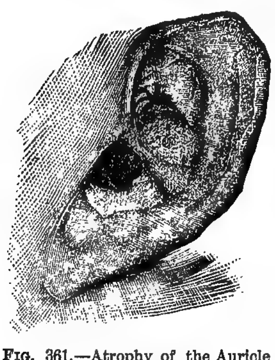


FIG. 361.—Atrophy of the Auricle due to Tubercular Syphilide.

A careful consideration of the more apparent symptoms of this disease will leave but little doubt in the mind as to diagnosis when a case is under observation. There are certain cases, it is true, of eczema, lupus, epithelioma, etc., which resemble the tubercular syphilide; thus Buck reports a case which he has diagnosed as an epithelioma, but which, from the local appearances described, might be taken for a tubercular syphilide.

For the treatment of late syphilitic eruptions see Syphilis.

NEW GROWTHS.—The following new growths are met with in the auricle: *a*, angioma; *b*, cavernous tumors; *c*, cysts (dermoid, sebaceous, atheromatous); *d*, epithelioma; *e*, fibroma; *f*, fibrosarcoma; *g*, lipoma; *h*, myxofibroma; *i*, myxosarcoma; *j*, nævus vascularis; *k*, sarcoma.

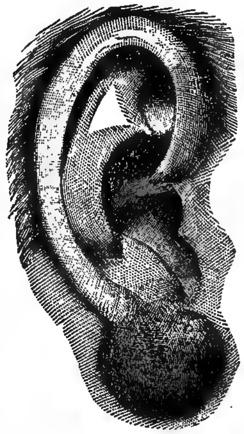


FIG. 362.—Sebaceous Cyst of the Auricle.

Cysts of the auricle are of frequent occurrence; the *sebaceous* variety found in the lobule sometimes attain large dimensions. Fig. 362 is an example of this variety from a photograph of a case in the writer's practice; the subject was a male, about twenty-four years of age. These growths should be removed with the knife, care being taken to extirpate the sac entire, or to cauterize it thoroughly, since there is a decided tendency to recurrence of the tumor. These cysts sometimes break down and their walls become the seat of inflammatory irritation; they then may remain open and continue to discharge for an indefinite period of time. Very often this atheromatous form of the tumor, however, has a small aperture only on its surface, which gives gradual exit to its contents.

Horny growths (*cornu*) may develop from atheromatous or dermoid cysts by means of the slow escape of their contents through this small opening, where a crust first forms, and then from continuous subdeposition becomes gradually elevated, and more or less conical in shape. These horn-like growths are probably due, in some cases, to epithelial proliferation from irritation of the skin. Fig. 363 shows a horny growth which came under the observation of Dr. Buck, and was extirpated with the knife. Burnett has also reported a case of this kind.

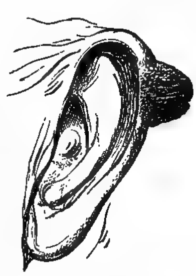


FIG. 363.—Horny Growth of the Auricle.

Fibroma.—These tumors, which are of various sizes, are found in the lobule. Piercing the lobule for the attachment of ear-rings sometimes gives rise to undue irritation, and these tumors are often thus produced. Fig. 364 represents a typical case of this kind in a girl thirteen years of age. The small nodule to be seen on the outer surface of the lobule marks the point where the organ was wounded by the piercer. These tumors require extirpation.

FIG. 364.—Fibroma of the Auricle.

Nævus vascularis, an example of which is shown in Fig. 365, taken from a photograph of a case in an infant which was brought to the writer's clinic at the New York Eye and Ear Infirmary, is usually congenital, and not of infrequent occurrence in the auricle. Its treatment is often unsatisfactory, especially in the young, owing to the difficulty in maintaining suitable dressings after any operation for its relief. The general management of nævi, which will be found under Affections of the Skin, does not differ from their treatment in other parts.

Sarcoma.—This is a rare affection of the auricle. The writer has seen but two cases, both of which were situated in the concha; both were removed by scissors, and the base of the tumor was scraped and afterward cauterized with the Pacquelin cautery. There was no return of the tumor in either case. Such tumors may, however, pursue a very rapid and malignant course, or after removal may return and produce metastasis; they are liable to bleed freely when removed.

WOUNDS AND INJURIES OF THE AURICLE.—*Cleft of the lobule* is frequently produced by the fine wire of ear-rings gradually cutting its way through the soft tissues from the weight of the pendant, or by being suddenly torn out. In some instances the wire seems to cut its way through so rapidly as to be followed by healing, a cicatricial line being thus left in its wake. Where several parallel lines are thus formed the points of exit give a serrated look to the border of the lobule. The loose tissue composing the lobule sometimes breaks down very rapidly under the inflammation excited by piercing and the subsequent introduction of ear-rings. Among such cases recalled to mind two are noteworthy, as occurring in sisters, where the same rings, made of fourteen carat gold, were employed. In both of these children the rings soon cut their way out and even a portion of the lobule sloughed off. This accident could not be altogether attributable to the base metal of which the rings were made. The lobules, in all the cases I have seen where such injuries occurred, were very thin.

An operation for the relief of the deformity where a slit remains in these cases is sometimes required; it consists in paring the edges of the notch with a small scalpel, but leaving a portion of the paring, a few lines in length, attached when cutting off the slice, as suggested by Knapp. This remaining fragment, when the raw edges of the two sides have been brought in contact with each other, is made to overlap and attach itself to a denuded surface on the opposite side of the notch, thus preventing the occurrence of any gap on the margin of the lobule after healing.

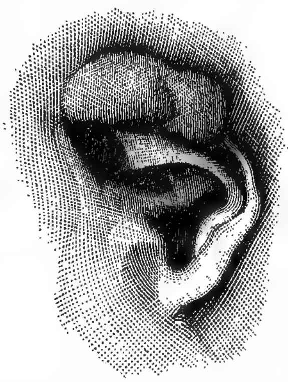


FIG. 365.—Naevus Vascularis of the Auricle.

Lacerated, contused, incised, and *punctured* wounds and injuries of the auricle are frequent, both in military and civil life, but in recent times surgeons have not feared to employ sutures in bringing the edges of the cartilage together, and, therefore, deformities of the organ from injuries do not often occur. Even where the auricle has been almost entirely detached from the head it may be successfully restored; the writer has seen two cases in men where, during childhood, the organ was nearly severed from its attachments, by the kick of a horse in one instance, and from the injury inflicted by a cartwheel, in the other; in both instances the wounds were dressed by persons who happened to be present, and did well. The position of the auricles was excellent in these cases so far as looks went, but it chanced that the meatus in both cases was closed by the cartilage of the concha. It is important that the surgeon shall avoid such a result by inserting a plug into the external auditory canal in such cases, and thus keep the meatus open until a cure takes place.

The auricular cartilage, in operations on the organ, serves the purpose of a splint, and when any bandaging becomes necessary we may avail ourselves of the unyielding cranial surface, over which the pinna is spread, to keep the parts in place.

Hæmatoma Auris.—This trouble is by far the most serious result of injury to the auricle. It is known in literature by various designations, its more prominent synonyms being as follows: othæmatoma, perichondritis auriculæ. This sanguineous tumor of the auricle is produced by a contusion. Some authorities allege that it may take its origin from idiopathic causes alone, but it seems to the writer that, even where a predisposition to its occurrence exists, its manifestation must be due to violence. The size of the tumor varies from that of a Lima bean to that of an egg. Fig. 366 shows a medium-sized othæmatoma in a sane person, due to a contusion. Its formation is usually rapid, and the sanguineous contents of the tumor, at first fluid, show a tendency, in some cases, to become clotted, and quite often, unless incised, spontaneous rupture takes place. The disease most frequently occurs in the insane. The inflammation in this affection is generally adynamic in character, and in a very considerable number of cases it shows a strong tendency to spontaneous recovery. The etiology of othæmatoma in the insane has long been a subject of discussion. Bird was at a loss to account for its origin, and Franz Fischer determined that the causes must ultimately be sought for in pathological states of the nervous system. One cannot witness the intense congestion of the ears sometimes accompanying great cerebral excitement in the insane without believing that othæmatoma may sometimes occur in consequence of very slight injury, when tissue-changes in the cartilage and perichondrium already exist. These nutritive changes seem to be mainly brought about through the agency of the nervous system, although some authorities lay much stress on the influence of blood-dyscrasias in producing changes in the blood-vessels of the part. The weight of evidence, however, leads to the conclusion that they most frequently depend on a morbid state of the brain, especially on congestion of the organ. (In this connection consult the paper of Dr. Achille Foville, published in Paris in 1859, and also the later publications of Dr. Brown-Séquard.) Functional disturbance of the brain, or of the cerebro-spinal centre, giving rise to disorder of the cervical sympathetic, may, by reason of the dominance thus exercised on the vessel-regulating nerves distributed on both the intracranial ganglia and the auricle, set up hyperæmia in the former and vascular changes in the latter. When othæmatoma occurs in the course of general paralysis, it would seem that auricular congestion takes place in consequence of the general degeneration of the sympathetic; and it has been suggested that in inflammation of the brain the aural disease becomes advantageous to the patient, since the hæmorrhage is thus spent upon the posterior auricularis, going from the middle meningeal. But while centric morbid conditions are justly regarded as of greatest importance, other impressions, propagated by morbid processes in other organs through the sympathetic system, are worthy of consideration; thus, in the examination of insane subjects having this affection, the almost universal prevalence of nasal catarrhs, diseased teeth, and, in the female, of uterine disease, is notable, and it is well known that the irritation due to these influences is transmitted through the nerves, and may not only aggravate cerebral disease itself, but is liable to also affect the organ of hearing. The predisposing factors believed to have an important relation to othæmatoma are as follows: Age (since it does not so often occur before adolescence), insanity, intemperance, cachexia, sex (the male being more liable than the female). All forms of mental disease seem to be predisposing, but the conditions most favorable to othæmatoma are present in acute dementia, where long-standing vaso-motor dis-

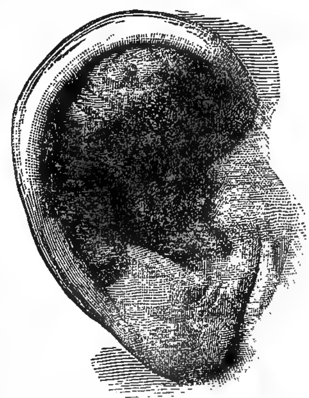


FIG. 366.—Medium-sized Othæmatoma of the Auricle.

turbances are followed by paroxysms of excitement. On the other hand, women are subject to a monthly aggravation of symptoms during the menstrual period, since the mentally sane, even, are more irascible and nervous at this time. The treatment of female lunatics, moreover, is more gentle than that of males, since their attendants are usually of their own sex, and less liable than male nurses to injure the ear in handling violent or idiotic patients. The ears of female lunatics are somewhat protected by their hair and head-dressings. In the mentally sound, the affection is most commonly met with among prize-fighters, gymnasts, persons given to violent sports, and among drunken and disorderly persons, whose blows and falls are frequent. From a careful study of the subject, the author has come to believe that othæmatoma, however great the predisposing causes, is finally always due to violence inflicted upon the auricle. Asylum superintendents, however, have been, on the whole, perhaps, rather disposed to undervalue the importance of mechanical causes, since it might be construed to imply undue restraint or rudeness in the management of their patients. But insane patients injure their own ears in various ways, and even those who are not violent, laboring under hallucinations of hearing, often maltreat their auricles in their efforts to gain relief from subjective sounds, pruritus, etc.

The more frequent occurrence of othæmatoma in the left ear has been the subject of much speculation. It has been suggested, that the close neighborhood of the left carotid artery to the heart affords a more direct supply of blood to the left ear, and that, furthermore, the left pinna is oftenest affected, because more liable to be pulled or struck by the right hand of the attacking party. The left ear, it is said, is also more exposed to injury in forcible feeding. These explanations, however, apply to mechanical agencies only. It has occurred to the writer that probably some vaso-motor influence might be found to lie at the bottom of the difficulty.

Othæmatoma very often develops equally on both sides —a fact suggestive of centric nervous origin. With regard to the symptoms of this complaint, the exudation is almost always confined to the outer surface of the pinna, owing probably to the fact that it almost invariably receives the impact of a blow with greatest force, and to the greater vascularity of this region. The affected organ is seldom very painful, even when the tumor is greatly distended or roughly handled. Sometimes the distention continues to progress rapidly, the walls becoming thinner in consequence of the stretching, until finally, in the worst cases, they undergo spontaneous rupture, unless relieved by an operation. These tumors, however, frequently pass through all the stages of the disease without either heat or pain being experienced by the patient. This variety manifests a disposition to develop slowly, and has a tendency to spread itself laterally rather than in thickness. Sometimes reabsorption comes to a standstill, and a considerable tumor remains for an indefinite period. In other instances a sinus is formed which may continue to discharge in spite of all attempts to obliterate the sac. In a very considerable number of cases the disease will terminate spontaneously in from four to eight weeks. It is worthy of note, in considering the retroactive consequences of this local trouble, that the posterior auricular artery, through one of its branches—the stylomastoid—communicates with the middle meningeal by anastomosis, thus establishing a significant and important relationship between the ear and the meninges of the brain. In sane persons this becomes a factor of serious import, and should not be overlooked.

Parts contiguous to the ear are sometimes implicated in an extension of the inflammatory process ; neuralgia may be kindled into action, and a general febrile action may supervene, but the middle ear, so far as is known to the writer, has never been invaded in this disease.

In forming our diagnosis of the affection, one almost constant causative agency should be first sought for, namely, trauma. The essential nature of the ailment depending upon a perichondritis of the auricle, its existence may be readily detected by an examination of the contents of the tumor, which will be found to be serous or sero-sanguinolent. The trouble may be distinguished from erysipelas by its well-defined sacculated appearance and the absence of the superficial changes common in the latter disease. Eczema and erysipelas, unlike othæmatoma, are liable to extend into the auditory canal. Other cutaneous affections, such as burns, phlegmonous inflammation, or tubercular syphilis, frequently invade the neighboring parts, especially the outer surface of the auricle ; none of them, however, leaves the deformity which characterizes othæmatoma. Nævi may resemble othæmatoma very closely in some instances.

Othæmatoma and idiopathic perichondritis of the ear should not be considered as separate and distinct affections, since it is well known that in no case of othæmatoma is perichondritis absent, and that, moreover, the contents of the tumor in othæmatoma are frequently serous.

A peculiar variety of othæmatoma remains to be mentioned as occurring in the insane, which is probably due to protracted and violent rubbing of the auricle. Any portion of the perichondrium may be involved, but it is usually limited to a small space. Thickening is often scarcely observable, and to the feel it is not "doughy." The deep-seated nature of the inflamed or congested region, however, may be discovered by stretching out the auricle between the observer's eye and a strong light. The effusion is not sufficient to form a tumor ; such cases seem to present the characteristics of the first stage of othæmatoma.

Deformity of the auricle to a greater or less extent is nearly always a result of othæmatoma. Figs. 367 and 368

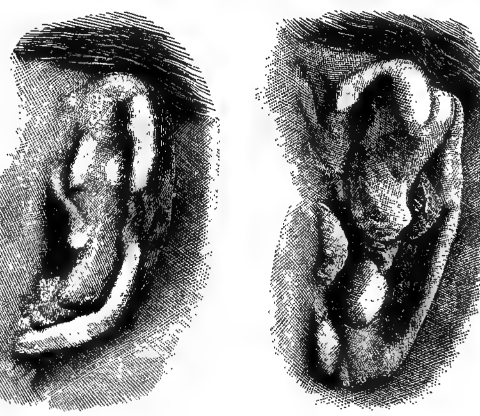


FIG. 367. FIG. 368.
Deformities of the Auricle due to Othæmatoma.

represent some of the strange and characteristic forms the organ may assume after healing takes place ; they are the same, it may be said, whether occurring in lunatics or in the mentally sound. Obliteration of the sac is accomplished by the union of its walls, and where the perichondrium has been greatly stretched by extreme distention it contracts upon itself as reabsorption takes place, and adaptation to the cartilage as before cannot occur ; the misshapen appearance of the cartilage increases with the continued contraction during the process of adhesion. The ear finally becomes indurated, the skin on the outer surface immovable. Sometimes the organizable lymph which obliterates the cavity enormously increases the thickness of the auricle, as in Fig. 368 ; but where a thin plastic layer only intervenes the auricle will be reduced in size, and often become even thin and shrivelled, as in Fig. 367.

In the treatment of hæmatoma auris it is a safe rule not to be in haste to interfere ; in general, it may be said that the dictum of Hippocrates, viz., that the employment of cataplasms and pledgets is to be avoided, is as safe a guide now as it was in his own day. It will also be well to remember that, whatever the supposed cause or causes

we have to deal with a perichondritis, in the treatment of which we should be guided rather by its character than by its cause. On the other hand, the expectant plan has sometimes been carried too far, since no treatment is *not* good practice in all of these cases.

Practically considered, othæmatoma has an aggressive and a retrogressive period. In the former the observer is seldom offered the opportunity of detecting the incipient symptoms. Generally a tumor is already found to exist, and the first consideration will then be to limit its extension, if possible. If it is found that the exudation is not active and that the quantity already present is not great, we may prescribe rest for the patient, and administer small and frequently repeated doses of the tincture of aconite root, with a view of arresting the rapidity of the circulation about the head. Locally, the affected portion of the auricle, and even beyond, may be enveloped with a coating of collodion, the general and uniform pressure produced by its contraction acting as a compress and thus promoting absorption. In the retrogressive stage, I have found dilute tincture of arnica of service, as in other contusions. When suppurative processes arise, as they sometimes do, in the connective tissue of the inner portion of the auricle, the peri-aural region, or that contiguous to the cartilaginous canal, the calcium sulphide (Calx Sulphurata of the Pharmacopœia) is indicated. As soon as absorption begins, or when that process is tardy, massage should be employed until a cure is accomplished.

Burns and *scalds* of the auricle are sometimes met with, but their treatment does not differ materially from such injuries in other parts.

Pruritus Auris.—A case of pruritus auris presenting some peculiar and perplexing features came under the writer's care several years ago. It was characterized by heat of the auricle, and excessive and tormenting itching in the external auditory canal of seven years' duration, without local lesion. The trouble seemed to have been transferred, after the application of a strong galvanic current, from the back, where it had previously existed, to its present situation. The local measures resorted to with most success consisted in irritating the skin of the back by means of painting with canthārideal collodion, and the application of a solution of sulphate of atropine to the external auditory passage. The patient's condition was thus very greatly improved, and a cure was finally effected. *Samuel Sexton.*

AUSCULTATORY PERCUSSION. The method of auscultatory percussion was devised by Dr. Cammann, and a paper upon the subject was written by Drs. Cammann and Clark (*New York Quarterly Journal of Medicine and Surgery*, July, 1840). Every form of matter has a percussion note peculiar to itself, or in other words, the quality, intensity, and duration of a sound depend upon the mechanical and chemical structure of the body producing it.

Now, if percussion be practised over bone and over the liver, the difference of the percussion notes is scarcely appreciable. If, however, a solid wooden stethoscope, made of cedar and cut in the direction of its fibres, be used, the difference in the percussion notes is marked. In the one case, the sound is diffused through the air; in the other, it is conveyed directly to the ear through a solid medium.

By this method the outline of the heart has been measured in all but its antero-posterior diameter in cases of pulmonary emphysema, or when the lungs overlapping the heart were consolidated; when the right or the left pleural cavities contained fluid; when effusion on the left side had pushed the heart to the right on to the surface of the liver.

By auscultatory percussion, the line of liver-dulness is found to extend an inch higher than by percussion. The position of the upper border has been ascertained when the right pleural cavity contained fluid, and when the right lung was consolidated, and the lower border has been found in cases of ascites. The border of an enlarged spleen has been traced where it was in contact with the liver, and in cases of ascites. It is necessary that the spleen should be in contact with the abdominal wall at least at one point. If it be separated by a fold of intestine or by fluid, it cannot be measured. The outline of the kidney, with the exception of the inner border, has also been found.

The capabilities of this method in the measurement of abdominal tumors, of uterine fibroids, of ovarian cysts, and in the differentiation of one from the other, and of all from cases of pregnancy; its possible use in the diagnosis of bony anchylosis, or of fractures, and in the recognition of union or non-union of the latter without removal of the splint, have been suggested, but have not received the full investigation that they deserve.

More attention has been paid to the measurement of the heart than to that of any other organ. It is most convenient to find eight points on the border of the heart at the extremities of four diameters. The four diameters are the vertical, running to the left of the sternum and the root of the aorta; the transverse diameter, at right angles to the above near its centre; the right oblique diameter, from the right auricle to the apex on a line drawn from the right shoulder to the apex; and the left oblique diameter, at right angles to the last named. All these diameters intersect one another at one point near the centre of the heart. From these eight points the outline of the heart can be drawn. In the original investigations these points were first marked on the cadaver. Sharp-pointed steel needles were then driven in, and the external parts removed. Usually the needles passed between the heart and pericardal sac, or just grazed the heart. When the right auricle was distended with blood, the needle at this extremity of the right oblique diameter frequently passed from one line to half an inch within the border of the heart, on account, probably, of coagulated blood being a poor conductor of sound, and the wall of the auricle being so thin as to have little effect on the percussion note. Having demonstrated the practicability of the method on the cadaver, the heart was next measured in the living subject. Here it was found that the measurement of the diameters in the dead body could not be taken as a standard of comparison for the measurement of those in the living. The reason is obvious; diastole occupies a longer time than systole, and, therefore, the measurement will usually be made during diastole. At this time the cavities of the heart are partially or entirely filled with blood; in the cadaver, on the other hand, it is rarely that all the cavities are equally filled; one or two may be distended, and the others empty. It is found, however, that, although the diameters, taken singly, are useless for purposes of comparison, if the sum of the diameters be taken, they closely correspond. The average of the sum of the diameters in the living adult male, from the measurement of a large number of cases, is sixteen and five-sixths inches. In practising this method over the heart, the stethoscope should be placed on a part of the chest with which the organ comes in contact. The difficulty of distinguishing the lower border of the heart from the liver may be considerable, as the percussion notes of the two organs are much alike. A little practice will overcome this difficulty.

The osseous sound from the ribs or the sternum sometimes is a source of embarrassment, but may generally be obviated by the use of the wedge-shaped stethoscope. Movement of the body, or of the integuments of the chest during examination, should be avoided. Percussion should be light, as a strong percussion note soon fatigues and confuses the ear. *Donald M. Cammann.*

AUSSEE is situated in a valley in the Austrian Alps, at an altitude of 659 metres (2,360 feet); it is a resort which owes its reputation as much to its fine climate as to its mineral springs. It is a few miles west of Selzthal, a station on the Rudolfs Railway, with which it is connected by regular stages. The water of Aussee is remarkable for the very great proportion of its solid constituents, prominent among which are the chlorides and the sulphates of sodium. Its composition, according to the analysis of Hauer, is as follows: Sodium chloride, 244.5; magnesium chloride, 7.5; sodium sulphate, 9.7;

potassium sulphate, 9.2; calcium sulphate, 1.7; magnesium bromide, 0.18; total solids in 1,000 parts, 272.7. The customary bath which is taken in reservoirs, having each a capacity of 850 litres, contains 9 Kgms. total chlorides.

As a beverage, this water is used in various dilutions and combinations, viz., as simple chlorinated water, as soda water, potash water, and brominated water, usually with the addition of more or less seltzer water. The bath-house, to which is attached a pleasant promenade, is under the care of the resident physicians, and here, in addition to the water-treatment, milk, whey, and vegetable juices are sometimes drunk. The season embraces the months of July and August.

The climate of Aussee is very equable, high winds are almost unknown, and the air is moist and balsamic. By reason of these characteristics the place is much frequented by sufferers from respiratory affections and nervous irritability. *Henry Fleischner.*

AUSTRALIA. Of the peculiar features characterizing the climate of the Australian Continent, of the great differences of temperature, etc., existing between different portions of this vast island, and of the beneficial effects derivable from more or less prolonged sojourn in the various provinces of this antipodal colony of Great Britain, as well as from the prolonged sea voyage necessary to reach its shores, there is much to be said. Such general discussion of the climate and climatotherapy of Australia, taken as a whole, the exigencies of publication render it impossible for the writer to undertake in this place. He would, therefore, beg to refer readers, for detailed information on these points, to the articles entitled Melbourne, New South Wales, and Victoria, which will appear in later volumes of the HANDBOOK, and to a general article under the title Australia, which will be found in the Appendix. *H. R.*

AUTEUIL is a French thermal station containing a single spring, the "Quicherat." Its waters are taken by invalids at the spring, and are also bottled for export. The chief elements of the water are the sulphates of calcium, iron, and alum. Passy is the nearest railroad station. *H. F.*

AUTOMATIC ACTIONS. By the term automatic actions, as applied to living bodies, we mean those movements which go on without any outside stimulus, the causes being in the body itself. For the sake of understanding them more clearly it is necessary to divide them into certain classes, which, so far as the higher animals are concerned, are as follows:

1. THE AUTOMATIC ACTIONS OF VEGETATIVE LIFE.—Under this head we have: (*a*) those of the respiratory neuro-mechanism; (*b*) those of the cardiac neuro-mechanism; (*c*) those of the vaso-motor neuro-mechanism; (*d*) the rhythmical movements of the stomach, intestines, spleen, and bladder.

The automatic actions in these classes may be modified by voluntary or other extrinsic influences, but they are, nevertheless, essentially independent of them. Thus the respiratory movements may be modified by volitional impulses, but they in the main go on rhythmically and independently. The mechanism of this process of automatism is well illustrated in the cardiac movements. The pulsations of the heart depend upon the stimuli rhythmically sent out by the intrinsic ganglia. The cells which originate these stimuli receive no excitation themselves except that furnished by the aliment from the blood. This aliment is constantly building up these motor cells into a more and more unstable condition. When the instability reaches a certain limit, the cell decomposes or explodes with a discharge of its force, after which it immediately begins to build up into instability again; and so the process goes on. This explanation applies to all the rhythmical automatic movements of vegetative life. The movements are performed by unstriped muscles, or the muscles of internal relation.

2. THE AUTOMATIC ACTIONS OF VOLUNTARY LIFE.—A second and much more striking class of automatic activities includes those involving voluntary muscles and the mind. They appear in various forms and in varying complexity according to the part of the nervous system which they involve. They may be divided as follows:

(*a*) *The Motor Automatisms.*—The harmonious movements of the eyes, the muscular adjustments called forth in the use of the voice, and of the jaws, mouth, and throat in suckling, are illustrations of motor automatism. The movements of the body and limbs in standing, sitting, walking, and in the various acquired dexterities, such as those of dancers, players, jugglers, acrobats, and skilled artisans, all are done automatically. Being, in man, acquired by practice, they may be spoken of as secondary automatic actions. They have for their anatomical substratum certain arrangements of nerve-fibres and cells in the cerebellum, basal ganglia, and spinal cord. The conscious mind, though taking no active share, first fathered them, and stands in ready connection with them. It starts or stops the machinery, just as by touching the pendulum we start or stop a clock that has been wound. Physiology teaches also that all voluntary acts tend by repetition to become automatic. For voluntary movements, by repetition, are more and more easily and quickly performed, until at last they no longer possess the elements, such as duration and intensity, necessary to arouse consciousness, and they are then done automatically.

(*b*) *Psychical Automatism.*—There is another class of automatic activities closely related with the foregoing. Here volition and normal consciousness have no share at all, and the whole psychical life, so far as it appears at all, is automatic. The mind becomes a real machine, working in certain established grooves, unmodified by any volition or by any external or internal stimulus except such as gives it the start; just as the boy trims the sails and fastens the rudder of his toy boat, then launches it to sail as its mechanism directs.

This psychical automatism is represented in lower animals by many of their instinctive acts. In following its instincts the animal obeys no conscious purpose, but is impelled by unfelt stimuli from within, these stimuli being furnished by the peculiar anatomical arrangements and nutritive needs of its nervous system, inherited from its ancestors. Instinct covers in the lower animals, however, both the acquired aptitudes and the psychical automatisms in man.

This psychical or cerebral automatism is perfectly illustrated in the conditions known as trance and somnambulism. Here consciousness, while not exactly abolished, is in an aberrant state (see Disorders of Consciousness), the will is suspended, but thought and feeling continue, and the body responds in systematized and apparently intelligent acts.

There are two distinctions which in a medical study of psychical automatism must be made: First, unconscious cerebration is a different thing from the psychical automatism which we are describing. The term unconscious cerebration should be limited to that very large share of our mental life which runs on beneath consciousness. Few persons, in carrying on a train of thought, bring every link in the logical chain into consciousness. We pass with a step from the first term to the last, the intermediate process being subconscious. In the association of ideas, one mental picture is often followed by another apparently remote, the missing links not rising into conscious view. Unconscious cerebration, therefore, refers simply to the subconscious part of our ordinary thoughts and feelings, and is one of the modes in which the mind naturally acts. Second, cerebral automatism, as understood by some writers, such as Carpenter and Luys, is made to include cerebral reflex acts, *i.e.*, all the mental acts which arise involuntarily in response to a stimulus. Thus we are told that the ready response of emotion at a dramatic climax, the instant formation of judgment where certain simple and common conditions are present, are all examples of cerebral automatism. From this same point of view, the common sense of mankind is but the automatically formed judgment upon the various affairs of life, which rises alike in the great mass of men. There is propriety in this view, and lines

of distinction must be somewhat arbitrarily drawn. Nevertheless, the acts referred to are much more typically reflex than automatic acts, as for example, when a novel situation excites at once spontaneously a burst of laughter. And it is better to limit the term cerebral automatism to those conditions of the mind in which spontaneity is abolished for a time and the psychical mechanism acts entirely apart from any conscious stimulus.

Cerebral automatism, as thus limited, is pathological and has a medical importance. It is a condition that is brought about by a number of causes, and makes a somewhat different clinical picture accordingly. Cerebral automatic states may be classified as follows: The epileptic, the somnambulic, the hypnotic, the automatism of inebriety, of insanity, of narcotic intoxication, of syphilis, of injuries to the head, and of over-work or cerebral exhaustion.

Epileptic Cerebral Automatism.—The automatic mental state which occurs in epilepsy accompanies much more frequently *petit mal* than *haut mal*. It generally follows the attack, but sometimes precedes it, and still more rarely takes its place, in which latter case the terms psychical epilepsy (Hughlings Jackson), masked epilepsy (Esquirol), epilepsia larvata (Morel) have been applied. It is a transitory psychical disturbance, and only one of several forms which occur at this period (see Epilepsy). Cases of epileptic automatism are numerous. In the simpler forms, the patient simply proceeds to do some ordinary but inapposite act. Often he begins suddenly to undress, or tries to go upstairs, and will climb upon a chair, or table, or shelf. Very frequently he puts some object near at hand in his pocket. Much more complicated acts may be done. A patient of Le Grand du Saule's, after an attack, found that he had taken passage in a steamer for Bombay. Gowers tells of a carman who, after an attack, drove for an hour through the crowded streets without accident. Trousseau relates the case of an architect who, when seized with an attack, would run quickly from plank to plank without falling; and Gowers, again, had a young lady patient who, during the epileptic automatism, would play the most difficult music. In some cases the emotional faculties are more involved, and attacks of transitory mania, or furious impulse, occur.

Artificial Cerebral Automatism, Hypnotism, Trance.—In the condition known as hypnotism, trance, mesmerism, "electro-biology," the phenomena of cerebral automatism are very perfectly shown, and an understanding of it gives the key to all the cerebral automatic states. In producing the hypnotic condition artificially in man his attention is first fixed upon some particular object, such as a bit of glass, which is held slightly above the level of vision, so as to put the ocular muscles upon a certain strain. After a few minutes, in sensitive subjects, the nervous force seems to lose its equilibrium and to concentrate itself in one particular direction. Little force is left to supply the rest of the conscious functions of the brain, and the whole mental life of the subject is narrowed into one field. The mind is but a point. The equilibrium of nervous force being once overturned, it continues unstable, and can be turned in one direction or another, according to the suggestion of the manipulator. Thus the hypnotic thinks that he sees a beatific vision, and every capacity of his mental being is expended on the feelings that such a vision excites. Or he is told that he is a murderer, and must die, and he is overpowered with fear and remorse. Or his mind is directed to the idea that one side of his body is insensible; he then feels no pain on that side. In any case, his mental energies are all so absorbed by some single dominant feeling, that ordinary sensory impulses coming up to the brain impinge fruitlessly upon consciousness, and awaken no sensations. The hypnotic is to all intents and purposes anæsthetic, blind and deaf to everything except an expected suggestion from the operator, which is the only link that holds him at the time to the external world. Under the domination of some particular idea or feeling, his mind may automatically cause him to perform many complex and apparently intelligent acts. The concentration of nervous force upon some particular function, such as that of sight, hearing, or touch, exalts these senses, so that vision is clearer, hearing more acute, and the touch more sensitive (see Hypnotism, Somnambulism). Such is, in brief, the physiology of hypnotic automatism.

Although the hypnotic condition is usually produced artificially, certain persons of a highly sensitive, nervous temperament are subject to spontaneous attacks, just as other persons suffer from the similar condition of somnambulism. Indeed, spontaneous hypnotic attacks are a kind of day-somnambulism. Individuals thus suffering are generally of a hysterical temperament, with deficient will-power, and their hypnotic attacks may accompany, or be complicated with, attacks of catalepsy, ecstasy, or hysterical seizures of various kinds. There are persons who have a congenital tendency to fall spontaneously into hypnotic states. Such was the case with a patient of Le Grand du Saule's, who, whenever he got into a state of excitement or expectancy, would fall off into a hypnotic sleep. Some of the reported cases of morbid somnolence belong to this class (see Disorders of Sleep). In other instances the tendency to spontaneous trance states is acquired, as in a case reported by Finkelnburg: a young woman having been once mesmerized by a professional, ever after was subject to spontaneous attacks of trance.

The condition of trance, or one closely allied to it, is induced voluntarily by the so-called trance-speakers. It may also be brought on by some periodically occurring affection, as was shown in a case related by Dr. B. F. Berkley (*Western Journal of Medicine and Surgery*, U. S., vi., p. 204). A married woman, aged thirty-nine, for years suffered from trigeminal neuralgia, which finally ended in a severe form of tic douloureux occurring every two weeks. After each attack she fell into a state of "somniloquence" lasting for an hour or two. During this time she would preach on religious topics with some amount of eloquence. She was a modern illustration of the similar states into which the priests of the Delphic oracle went when uttering their prophecies.

Hypnotic states are generally brought to an end by the passes of the manipulator. If left alone the state continues for some hours, passing finally into true sleep, from which the patient awakens spontaneously. In some persons who are subject or have been subjected to periodical attacks of hypnotism, the mind recalls in one attack what occurred in the previous one. After coming out from an attack there is no recollection, as a rule, of what was done in it. There are considerable variations in the degree or intensity of the hypnotic state. In the slighter degrees it resembles considerably that of profound reverie or abstraction. There is a distinction, however, between the absorbed reverie of the student and the absorbed contemplation of the hypnotic. In the former case the mind is constructing and building under a certain kind of voluntary direction; in the latter the mind is going automatically over old ground.

Traumatic Cerebral Automatism.—Very rarely injuries of the head produce such a pathological change in the brain as to make the person injured the subject of periodical attacks of cerebral automatism. In these cases the mental condition is the same as if the patient walked in his sleep or had been artificially hypnotized.

One of the most typical cases of this kind is that related by Mesnet, of the French soldier who, after suffering from a severe injury of the head, used to pass into automatic states lasting for days. He would then unconsciously go through all the routine actions to which he had been accustomed, such as dressing, taking a walk, smoking, etc.

The Cerebral Automatism of Inebriety.—Dr. T. D. Crothers has related some remarkable cases in which the effect of the long-continued abuse of alcohol has been to induce periodic attacks of cerebral automatism. The patients fall into a state very much resembling that of hypnotism. In this condition they may go through the ordinary routine of life in so perfect a manner that no one would recognize the peculiar aberration of the mind. After a period of hours, or even of a day or more, normal consciousness returns and they remember nothing of what they have been doing. One of the most remarkable illustrations of this kind was that of a railway

conductor who, after passing into the automatic state, would take charge of his car, run the train, collect tickets, make change, and do all the other duties of his position. Finally, after returning home and awaking, he could remember nothing of what he had done.

Briefer and less typical attacks of cerebral automatism occur undoubtedly in very many cases of chronic inebriety.

SYPHILITIC CEREBRAL AUTOMATISM.—Cerebral syphilis sometimes produces states of automatic mental action, though these are not of a very typical kind. The syphilitic poison causes a kind of somnolent or stuporous condition, in which the patient appears incapable of voluntary intelligent acts. When roused and set upon ordinary tasks or routine duties, he goes through them automatically and almost unconsciously.

THE AUTOMATISM OF BRAIN EXHAUSTION AND BRAIN DISEASE.—Luys ("The Functions of the Brain," p. 183) relates the history of a young man who had been for several days engaged in making calculations of compound interest, which had caused a great tension of his mind. One evening, after dinner, he was about to go to sleep when, as he says, "Without the slightest encouragement on my part, in a state between sleeping and waking, I began, without the smallest volition on my part, to calculate and go over again exactly the same problems as when in my office. The cerebral machine had been set in motion too violently to be stopped, and this involuntary work went on in spite of me, and in spite of all the means I endeavored to employ to cause its cessation, that is to say, for from about three-quarters of an hour to an hour and a quarter." Many persons, after an evening of exhausting study, on retiring to bed have experiences somewhat similar to the above. Healthy persons also discover a little of this cerebral inertia in their disinclination, or even absolute inability, voluntarily to leave a task in which they are absorbed.

Dr. O. C. Gibbs (*Pennsylvania and Independent Medical Journal*, ii., p. 12, 1859) relates the history of a large, muscular man, aged fifty-five, who showed, in a permanent and exaggerated form, this kind of automatic condition. The person in question had been a hard drinker and smoker, but had suffered from no disease. His family at last noticed, however, that his mind was somewhat affected. His memory failed, and he would tell the most absurd stories. Gradually his intelligence diminished and his will became impaired. When he began to do a certain thing he had no power to stop himself. If he went to the barn to throw down hay he would never stop unless interfered with, until he had pitched off the whole mow. If sent out to bring in an armful of wood he would never stop until the pile was all in, or the room was full. When he once commenced to eat, it seemed as if he could never cease. As his mind became more affected he gradually lost the power of balancing himself, and showed a constant tendency to go backward when standing, and to tip over backward when sitting. He slept much. His strength gradually failed, and he died with no marked symptoms. The diagnosis of cerebral softening was probably correct, although no post-mortem examination was made.

THE CEREBRAL AUTOMATISM OF INSANITY.—The condition of cerebral automatism has been described as a form of insanity. But, on the other hand, there are forms of insanity in which cerebral automatism appears as part of the phenomena of the disease. Thus, maniacal states, especially those of epilepsy, the impulsive acts in the various states of defective mental inhibition, may be looked upon as automatic.

Perhaps the automatic cerebral life in the insane is best shown in acute dementia, where only the lowest of the mental functions remain, and the sufferer is guided only by the impulses and stimuli of his vegetative system.

In secondary dementia, and in idiocy and other states of mental enfeeblement, the mental activities, so much as remain, are more or less automatic.

MEDICO-LEGAL RELATIONS OF CEREBRAL AUTOMATISM.—In conclusion, I have only space to call attention to the very evident medico-legal importance of a knowledge of cerebral automatic states. This applies especially to the more frequently occurring forms, such as those of artificial, epileptic, and possibly inebriate, automatism. There is no doubt that a cerebral automatic is irresponsible, morally, for his acts, and except in inebriate automatism, the courts would sustain the medical view. Unfortunately, it is as yet practically almost impossible to demonstrate by objective tests that an accused person was really in an automatic state. *Charles L. Dana.*

AVA, AWA KAVA, etc. These and other words are the English approximations to the name of an intoxicating drink made by the South Sea Islanders, from the roots of *Piper Methysticum* Forster (*Macropiper Methysticum* Miquel); Order, *Piperaceæ.*

This plant is a diœcious shrub, with large, long-petoled, oval leaves, and small, simple flowers, in catkins.

The root, which is the part used, is soft and juicy when fresh, but becomes very light upon drying. It is light-gray in color externally, and pale yellowish-white when cut. It comes in large, thick, clumpy pieces, often eight or ten centimetres across at the base of the stems, and divides quickly into several crooked, irregular branches. The texture is woody, but soft and light; the sawed surface is dusty or mealy. The odor is slight, the taste rather spicy and bitter, leaving the tongue slightly benumbed for a little while. A transverse section shows a thin bark, and a radiated, woody ring, in which the narrow woody edges are separated by broad, starch-bearing, medullary rays.

Ava grows in numerous islands of the Pacific Ocean. The most important constituent is a soft, yellowish resin, called *kawin*, separated by Mr. Gabbey (1860), of which the root contains two per cent. It has an aromatic and spicy taste, and is probably the active principle. A crystallin principle, *methysticin*, was discovered many years before (1845), by Morison, and can be obtained by concentrating a tincture of ava and allowing it to stand. The methysticin crystallizes out in needles, and can be purified by recrystallizing from alcohol. It is a neutral, tasteless substance, sparingly soluble in cold, but more freely in hot, water; easily so in alcohol and ether. The yield is about one per cent. Ava contains also nearly one-half of its weight in starch.

ACTION AND USE.—The drink "awa" is prepared and used in the Sandwich Islands, according to Dr. Th. Toel, of Honolulu, in the following singular and sociable manner: "The root is chewed, and the juice so extracted is spitted into a vessel which stands in the centre of the participating circle of friends. Each mouthful is chewed as long as the saliva gives the least taste, and then laid aside. When the supply of the root is exhausted, little cups (*sic*) are made of the chewed portions, while the expectorated liquid is allowed to stand and ferment. Then, after a full meal, they drink it, either from the "cups" (sops ?) just mentioned, or directly from the public bowl. The action is almost immediate, and they settle to the ground in a deep, drunken slumber, which lasts several hours, from which they awake refreshed, and without any disagreeable symptoms. The taste of the drink is so bitter that they usually take cocoanut-milk or fruits with it." Excessive use of it produces a chronic, troublesome, scaly disease of the skin. The urine, after a preparation of ava root is taken, is abundant and pale, and appears to be decidedly soothing to the mucous membrane of the genito-urinary passages. It is also a sudorific, but not very reliable in this respect. In small doses it is an unirritating bitter tonic. The Sandwich Islanders have used it considerably in gonorrhœa, with encouraging success. The pain and discharge are said to be rapidly reduced by it, and the cure made quickly and pleasantly. One or two grams (grs. xv. ad xxx.) several times a day, in hot infusion, is recommended. Alcohol extracts its properties most completely, but for other reasons may not be so desirable.

ALLIED PLANTS.—The genus *Piper* is a very large one, containing one hundred species of shrubs or climbers in all tropical regions. Pepper, cubebs, matico, etc., are among the most widely known. See PEPPER.

Allied Drugs.—In its effects upon the nervous system, ava recalls *Cannabis Indica.* How far it may be compared to Jamaica dogwood, picrotoxin, etc., our knowledge of all is too incomplete to say.

W. P. Bolles.

AVÈNE, a French thermal station, eight kilometres (five miles) distant from Montpellier, in the department of the Herault, lying at an altitude of 287 metres (800 feet) above the sea. The water of the single spring has a temperature of 28° C., and contains only 0.33 part total solids per 1,000, of which 0 021 is sodium arsenate. Avène is frequented by patients suffering from skin affections and various diseases of the eye and ear. The water is used in the form of irrigation. *H. F.*

AVENS (*Benoite* Codex Med.), *Geum urbanum* Linn. The *Geums* are perennial herbs, with the general characters and qualities of the *Potentillas*, but differ from them in their styles, which are persistent, stiff, long, and kinked, or variously bent. They project in all directions from the fruit, making it a sort of burr. *Geum urbanum* Linn. Avens, Order *Rosaceæ, Potentilleæ*, is a straggling herb with a branched stem, ragged-pinnate leaves, and yellow flowers.

The rhizome is the portion used. It is short and thick (one centimetre or so in diameter), dark-brown, rather hard and brittle when dry, and furnished with numerous fibrous rootlets. Its odor, when fresh, is spicy (it has been called clove root), but as it is seen in the shops it scarcely has any. Its taste is astringent and slightly bitter.

The constituents of avens are: *tannic matter*, which is abundant; a bitter substance, not yet obtained in a state of purity (*Geum bitter*), and an *essential oil.*

Geum has been used as a substitute for cinchona, also more extensively as an astringent. For the first purpose it has no more claim to notice than other plants with bitter juices. Its aromatic value is almost nothing. Dose, as an astringent, two grams (2 Gm. = gr. xxx.).

Allied Plants.—*Geum rivale* Willd., of the United States and Europe, has similar qualities to the above. Numerous other geums are astringent, as well as several other closely related genera (see Tormentil).

Allied Drugs.—For a list of astringents see Nutgalls. *W. P. Bolles.*

AVON SPRINGS. Location and post-office, Avon, Livingston County, N. Y.; on the Erie Railway, eighty-five miles east of Buffalo. Discovered in 1792, though never vigorously advertised, these springs have always been substantially patronized. There are four springs: the Upper, Lower, Congress, and Magnesia. They all contain sulphuretted hydrogen in marked proportion. The analysis of the Upper Springs will serve as a type of the rest, though the Congress is much stronger in its sulphur constituent.

In a wine gallon, solid contents:

Sulphate of magnesia	10 grains.
Sulphate of lime	84 "
Sulphate of soda	16 "
Carbonate of lime	8 "
Muriate of soda	18.4 "
	136.4 "

Gaseous contents of a wine gallon:

Sulphuretted hydrogen	12 cubic inches.
Carbonic acid	56 "

Therapeutic Properties.—These are strong sulphur waters, and have proved valuable in affections of the skin, rheumatism, dyspepsia, etc. On account of the large proportion of Epsom salts which some of them contain—Lower Spring—aperient and cathartic effects are readily obtained, and by heating and driving off the sulphuretted hydrogen, the water is rendered quite palatable. Extensive bath-houses are provided, and skilled attendants regulate the duration and temperature of the bath.

There are numerous hotels, some of which are first-class. The situation of Avon, in the fertile and picturesque valley of the Genesee, commends itself for healthiness, beauty, historical and romantic interest. The population of the village is about three thousand five hundred. There are four churches, two schools, a bank, public parks, etc. The climate is equable, the drainage natural. The ordinary drinking-water is limestone.

Geo. B. Fowler.

AX, a small town of France, in the Département de l'Ariège, lying at an altitude of 711 metres, possesses a large number of thermal springs, varying in temperature from 35° to 77° C. (95° to 170.6° F.). The waters are employed as baths, both general and local, douches, inhalations, and as a beverage. The diseases most benefited by a course of the waters at Ax are rheumatic affections, catarrhal inflammation of the respiratory organs, skin diseases, and disorders of the lymphatic system. Chemically the water of Ax belongs to the class of sulphurous waters. Its main constituents are sodium sulphide, sodium chloride, various sulphates and carbonates, silicic acid, and organic matter. The springs, les Canons and le Rossignol, having respectively a temperature of 75° (167° F.) and 77° C. (170.6° F.), are the warmest waters, and contain the greatest amount of sodium sulphide. Protracted bathing produces temporary cyanosis, which, according to Filhol, is due to the excess of silicic acid. Ax is 42 Km. (about 26 miles) distant from the Station Foix (Chemin de fer du Midi), and its repute is steadily on the increase. Its climate is salubrious and invigorating. *H. F.*

AXILLA, Surgical Anatomy of.—The axilla (*ala*, a wing) is the space which exists between the upper arm and side of the thorax. It is of a pyramidal shape, and is bounded in front by the pectoral muscles, behind by the subscapularis, teres major, and latissimus dorsi, on the inner side by the serratus magnus, intercostal muscles and ribs, and on the outer side by the upper part of the arm and shoulder-joint. The base is formed by the skin stretching between the anterior and posterior boundaries. The hollow between the anterior and posterior folds is commonly known as the armpit, but anatomically we imply more by the term axilla than this depression: we include all the deeper space which reaches up to between the scalene muscles, and contains the axillary vessels, brachial plexus of nerves, and lymphatics. This deeper space is surgically continuous with the neck.

Superficial Anatomy.—The skin of the armpit proper, which is very thin, sensitive, attached to the fascia beneath, and of a darkish color, is supplied with glands which secrete an odorous sweat. In some cases this sweat is of a peculiar color, and stains the linen; it may be large in amount and cause great discomfort to the individual and his friends from the disagreeable odor emitted.

The skin of the armpit is abundantly provided with hairs which never grow to any great length; their limit is generally well defined, the outer border furnishing a good surface mark for the axillary artery in the third part of its course.* The armpit is of different depths in different individuals; in women and children it is not so well marked as in men, chiefly because in them we have less muscular development and more adipose tissue. When the arm is lifted above the head the depression almost disappears and the skin is put so much on the stretch that nothing can be felt of the deeper part; the depression deepens as the arm is lowered to the side, the skin being relaxed and thrown into folds. The fingers can now be pushed high enough to feel the head of the humerus. When it is necessary to examine the deeper structures, the arm ought only to be slightly drawn away from the side. In opera-

* According to Mr. A. W. Martin (Edin. Med. Journal, June, 1884): "The presence of hair in the pubic region is sufficient, by the law of correlation of growth, to account for the presence of hair in the corresponding part of the fore-limb, the axilla." He also says that the hair of the axilla has a fixed ratio to that of the pubes and also corresponds closely in color; he regards sexual selection as sufficient to account for it in the pubes, and also remarks that its quantity in both sexes will be in proportion to the sexual passion. With this last statement I certainly am not prepared to agree.

tions on the axilla the arm should always be abducted and raised to lessen the depression.

It is not uncommon to see suppuration of the follicles in this region; these small follicular abscesses, owing to the sensitiveness of the skin, are very painful and should be opened early.

The skin covering the anterior fold is thick, not closely adherent to the deeper structures, and free from hairs. Close below the clavicle and internal to the shoulder, the coracoid process can be felt. Here is seen a well-marked depression called the infraclavicular fossa, which marks the triangular cellular interspace between the clavicular origins of the deltoid and pectoralis major muscles. At this point it is possible to compress the axillary artery against the second rib. A line drawn from the middle of the clavicle to the inner side of the prominence formed by the coraco-brachialis muscle would give the course of the axillary artery.

The lower border of the great pectoral muscle follows the line of the fifth rib; the first visible serration of the serratus magnus on the inner side of the space is the sixth. The posterior fold is thicker than the anterior on account of the great thickness of the teres major muscle. When the arm is raised from the side the axillary artery can be felt pulsating as it passes into the arm, and may be easily compressed.

FASCIA.—On removing the skin from the axilla we come upon a strong fascia, the disposition of which it is important to know because of its influence on the course of abscesses, which not infrequently form in the neighborhood. The strong fascia which covers the great pectoral muscle and is attached to all the subcutaneous bony prominences, winds round its lower border and splits into two portions, one of which continues to ensheath the pectoralis muscle on its inner surface, while the other forms the floor of the axilla and, after covering the latissimus dorsi and teres major muscle, passes upward and backward and is lost in the strong deltoid aponeurosis. The portion of this fascia which covers the pectoralis major muscle externally sends a process between it and the deltoid muscle which becomes continuous with the costo-coracoid membrane.

The Costo-coracoid Membrane (Fig. 374) is a strong aponeurosis which is continuous with the deep cervical fascia; it splits to enclose the subclavius muscle, is attached to the clavicle, to the coracoid process, and is continued to the capsule of the shoulder. It is also attached to the cartilages of the first and second ribs, and is continuous with the aponeurosis over the serratus magnus muscle. This fascia is the costo-coracoid membrane proper, and covers the first part of the axillary vessels and nerves. When it reaches the edge of the small pectoral muscle it again divides to enclose it; reuniting again it passes down to the base of the axilla, and becomes attached to the skin and the fascia covering the great pectoral; externally it is continuous with the brachial aponeurosis. Gerdy calls this process the *ligamentum suspensorium*, because he says it is the ligament of the skin of the armpit, which it pulls upward. This suspensory ligament, then, divides the axilla into an anterior and posterior compartment, the posterior containing blood-vessels and nerves, and the anterior, the loose cellular tissue which separates the two pectoral muscles and intervenes between the lower part of the fascia and the great pectoral. Now, when an abscess forms in front of the suspensory ligament, that is, below the small pectoral or between the two pectorals, it would tend to point at the lower border of the anterior axillary fold, or in the interspace between the deltoid and the great pectoral muscle; but if pus forms behind the suspensory ligament and is not evacuated early, it may burrow into the neck and thence find its way, through the upper opening of the thorax, into the mediastina; it may also find its way beneath the latissimus dorsi and point in the back, or it may burrow into the subscapular fossa and thence get into the shoulder-joint. Abscesses in the axilla should be opened early and after the manner of the late Mr. Hilton. He advised that the skin alone should be cut with a knife, that a grooved director should then be pushed into the deeper structures till pus wells out. The deeper parts may be still further opened up by introducing a pair of dressing forceps, opening them widely in the abscess and withdrawing them open. If axillary abscesses are opened in this way, there is no danger of wounding any of the displaced vessels in the neighborhood, as they are pushed aside by the director. The finger answers often quite as well as a director.

BOUNDARIES OF THE AXILLA.—*Anterior boundary* (Fig. 369).—This boundary is formed by the two pectoral muscles, the great pectoral alone forming the lower border of the anterior fold. It is important, surgically, to remember that the fibres of the large pectoral go downward and outward, and those of the lesser upward and outward. The interspace between the great pectoral and the deltoid may be often very small or wanting, and the division between the two muscles can only be made out by the position of the cephalic vein and a branch of the acromial thoracic artery.

Owing to the pectoralis major muscle having an origin from the clavicle, it is necessary, in fracture of that bone, that the arm should be placed close to the side to prevent the muscle pulling down the inner fragment, and so delaying union. In females the lower edge of the anterior border of the axilla, owing to the presence of the mammary gland, is not so easily seen as in the male. In the female the mammary gland moves freely on the great pectoral muscle, there being an abundance of cellular tissue between the muscle and the gland; but in advanced cases of cancerous disease of the breast every movement of the pectoral muscle is painful because of the gluing together of the breast and the muscle by infiltrated tissue.

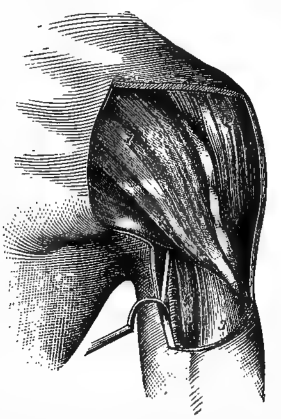


FIG. 369.—Skin and fascia have been removed. 1, Pectoralis major; 2, deltoid; between these muscles is seen the cephalic vein; 3, biceps; 4, coraco-brachialis, close to which lies the brachial artery and the median nerve drawn to one side. (After Roser.)

The acromial thoracic vessels, and the internal and external anterior thoracic nerves are seen on the inner surface of the pectoral muscle. The long thoracic artery generally runs along the lower border of the lesser pectoral.

In rare cases the great pectoral muscle is wanting altogether, or the clavicular portion alone may be wanting. The lesser pectoral may be attached to as many as five ribs, or as few as one. Its insertion may be transferred from the coracoid process to the coraco-brachialis muscle or humerus itself.

Posterior boundary (Fig. 372).—The posterior wall of the axilla is formed by three muscles which are supplied by the same set of nerves, viz., the three subscapular, and all three muscles are internal rotators of the humerus. The tendon of the latissimus dorsi, with the teres major, form the lower edge of the posterior fold, the posterior wall of the deeper portion being principally formed by the subscapularis. The axillary vessels rest on this posterior wall, held together by a dense cellular sheath, and separated from the rest of the axilla by the above-described suspensory fascia.

Internal boundary (Fig. 370).—The inner wall of the space is formed by the ribs, intercostal muscles, and the upper digitations of the serratus magnus. On this wall, which is somewhat convex, a large nerve is seen running down in a vertical direction, to be distributed to the serratus magnus muscle. This nerve is a branch of the brachial plexus, and is called the long thoracic. We also find here branches of the posterior and long thoracic vessels. Abscesses and tumors, as a rule, lie along this wall, and are fortunately well away from the axillary vessels; in removing tumors we always dissect toward the inner wall.

External boundary.—The external boundary of the axilla is formed by the upper part of the humerus and coraco-brachialis muscle; along this boundary, and on the inner side of the coraco-brachialis are seen the axillary vessels and nerves closely bound down by their fascial covering.

The *inferior boundary* or *base* of the axilla, which is formed by the skin and fascia stretching between the anterior and posterior folds, has already been described.

The Apex of this cone-shaped space may be said to be continuous with the posterior triangle of the neck, as vessels, nerves, lymphatics, cellular tissue, and fascia reach the axilla from the neck through this apex. It is the space between the upper edge of the scapula, clavicle, and first rib. Abscesses of the neck have been seen passing through this opening and pointing in the axilla.

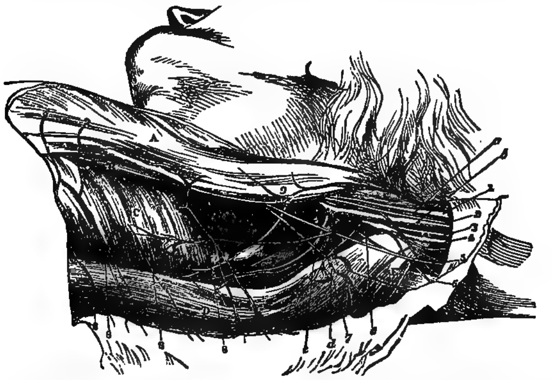


FIG. 370.—View of Axilla, showing Anterior and Posterior Folds with the Internal Wall; also Showing Lymphatic Glands. A, pectoralis major; C, serratus magnus; D, latissimus dorsi; E, teres major; F, Subscapularis; a, axillary artery; b, axillary vein. (After Ellis.)

CONTENTS OF THE AXILLA.—The axillary vessels, with the lymphatic glands, fat, and loose cellular tissue, are the principal contents of the axilla. The loose cellular tissue permits of free movements of the arm to and from the body, but it also permits of the collection of large quantities of blood and pus. The vessels and nerves are bound together by a sheath of thick cellular tissue; they lie on the outer wall of the space internal to the coraco-brachialis.

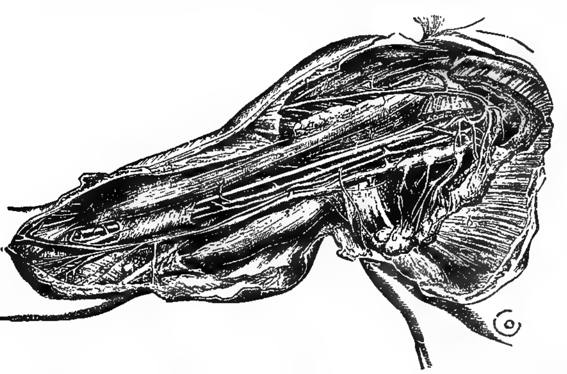


FIG. 371.—Dissection of Axilla, showing the Axillary Vein (2.2) and Parts in Relation with it. 1, 1, axillary artery; 2, 2, axillary vein; 3, 3, basilic vein; 4, cephalic vein; 5, 5, pectoralis minor; 6, axillary glands.

Axillary Vein (Fig. 371).—This is the most superficial of the contents of the axilla. In the upper part of its course it is so fixed by fascia connecting it with the coracoid process and pectoralis minor muscle, that if wounded it tends to gape, and air is apt to enter. The vein is formed by the junction of the venæ comites with the basilic vein. This union may occur low down or high up; the normal point of union is at the lower edge of the subscapularis muscle, though the junction not infrequently takes place higher up, sometimes as high as the clavicle. It is always shorter than the artery, measuring about 7.5 ctm. (three inches) in length. Union occurring high up complicates operations upon the artery, owing to the numerous transverse communicating branches which cross the artery. The vein lies to the inner side of the artery, and generally overlaps it. When the arm is drawn away from the side it almost altogether covers the artery. In its course through the axilla, this vein receives many tributary branches, the largest of which is the subscapular. It receives the cephalic vein immediately above the lesser pectoral muscle. In operations on the axilla, the vein and its branches are frequently wounded—more often than the artery—but it is rarely injured by external violence. In reducing dislocations of the shoulder, and using extreme traction, the artery is much more frequently injured than the vein, owing to its proximity to the heart and its fixed position; the vein, when wounded, bleeds freely, and there is great danger of air entering it. This accident has many times occurred, especially in operations for removing diseased glands, and not a few fatal cases are on record. It is always well before dividing the veins, especially about the neck and axilla, to tie them with a double ligature and cut between.

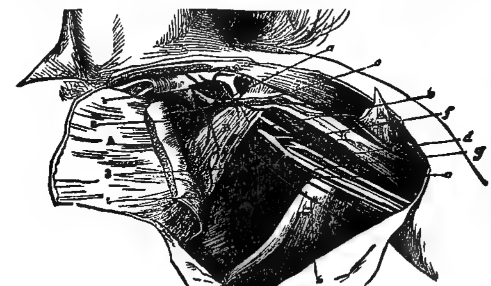


FIG. 372.—View of Axilla, showing Axillary Artery (*d*) divided into Three Portions by the Pectoralis Minor Muscle (B). E, axillary sheath; F, subscapularis; G, latissimus dorsi; H, teres major; *a*, acromial thoracic branch of axillary artery; *b*, long thoracic; *c*, subscapular branch; *g*, axillary vein.

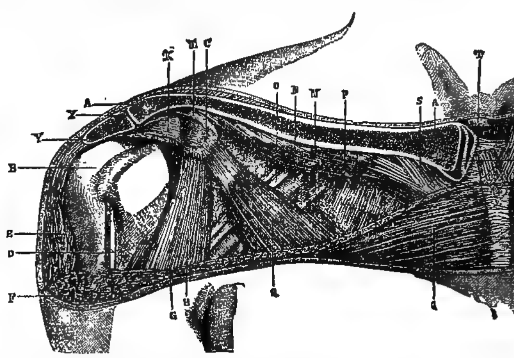


FIG. 373.—Portion of Clavicle and Acromion Process removed with Pectoralis Major and Deltoid Muscles. Pectoralis minor muscle (R) crossing the space; relation of axilla to the shoulder shown, and also contents of axilla; M, axillary vein; N, axillary artery; O, brachial plexus; P, subclavius muscle. (From Anger's "Anatomie Chirurgicale.")

In almost all diseases of the axilla there is swelling of the arm caused by pressure on the veins and absorbents.

Axillary Artery (Figs. 372 and 373).—This vessel, which is the continuation of the subclavian, extends from the lower border of the first rib to the lower border of the teres major muscle: it measures about fifteen centimetres (six inches) in length, and its direction is altered with the position of the arm. When the arm is close to the side it forms a curve having its convexity upward and out-

ward; when the arm is held at right angles to the body, the artery is in almost a straight line; and again, when the arm is held above the head, the slight curve thus formed has its concavity upward. Its upper portion lies close to the chest and rests on the upper serrations of the serratus magnus; the long thoracic nerve is behind it, and in front is the costo-coracoid membrane. Its lower part lies principally on the subscapular muscle. The vein is superficial to the artery above, and the nerves of the brachial plexus lie to its upper and outer side; lower down the vein becomes more internal and the nerves surround the vessel, the two heads of the median embracing it. For convenience of description it is divided surgically into three portions, the part above, beneath, and below the pectoralis minor muscle. It lies deepest above this muscle and is most superficial below it. The large thoracico-acromial branch is given off immediately above the pectoralis minor, and might be wounded in the operation of tying the axillary in its first part. A number of small branches are given off which are not surgically important. The subscapular artery, given off near the lower edge of the subscapular muscle, is a large branch, which runs to the side of the chest and near its origin gives off the dorsalis scapulæ. The external mammary is given off below the lesser pectoral, and is sometimes of large size; it is always cut in the operation of excision of the breast, and may give rise to slight hæmorrhage. The circumflex arteries closely embrace the neck of the humerus, and should be looked for and avoided in excision of the head of the humerus. In wounds of the first part of the axillary artery the vein is so closely in relation with it that it rarely escapes; lower down the artery may be wounded and the vein remain intact. Dr. George Fenwick, of Montreal (*British Medical Journal*, September, 1883), relates a case of wound of the third part of the axillary artery, due to fracture of the neck of the humerus. The vein was uninjured; the site of the ruptured artery was detected by the stethoscope; the artery was cut down upon and ligatured at the point of injury, and the patient made a good recovery. The artery is usually tied in the third part of its course, where it is most superficial. It has been tied on the first part, but owing to its depth and the thick covering of muscle, and also its close connection with the vein, ligature of the third part of the subclavian is preferred, as being the safer and simpler operation. The third part of the subclavian is more easily compressed than the first part of the axillary.

Aneurism not infrequently affects the axillary artery; this is, perhaps, owing to its nearness to the heart and to the curve the artery makes at its upper part. It has been occasionally ruptured in reducing dislocation of the shoulder.

Nerves of the Brachial Plexus (Fig. 374).—These nerves are derived from the lower four cervical and first dorsal. They are to the outer side of the artery in the first part of its course, but lower down surround it. When the axillary artery divides into two trunks, one of which gives off all the branches, this latter is, as a rule, embraced by the two heads of the median. The axillary nerves are rarely torn by traction on the limb; when forcibly stretched they may be torn away from their attachment to the cord in the cervical region, as in a case recorded by Flaubert, where this accident happened in endeavoring to reduce a dislocated shoulder. The median is the nerve most frequently injured in wounds of the axilla, the musculo-spiral, from its very deep and protected position, always escaping. The axillary nerves are occasionally injured in fracture of the neck of the humerus, and may be compressed in dislocation of the shoulder.

Lymphatics (Fig. 370).—The axilla is richly supplied with lymphatic vessels and glands. The glands, which are ten or twelve in number, are mostly placed along the axillary vessels and form a continuous chain with the cervical glands. They receive the lymphatics of the arm, and are often much enlarged in inflammatory affections of the hand and arm. A few glands are situated on the serratus magnus muscle and near the lower edge of the pectoral muscles. They receive the lymphatics from the side of the chest and mamma, and also the superficial lymphatics of the abdomen as low down as the umbilicus (Treves). These are the glands which are first enlarged in certain affections of the breast, *e.g.*, cancer, and also when the chest or abdomen is inflamed superficially, as from blistering, etc. Their efferent vessels join the axillary glands. There are some glands situated at the back of the axilla along the subscapular vessels; these receive the lymphatics from the back. In the interspace between the great pectoral and deltoid muscles near the clavicle, one or two small glands are found; they receive the lymphatics of the shoulder and outer side of the arm; above, they are connected with the lower cervical, and below with the axillary glands. The efferent vessels of the axillary glands pass up with the subclavian vein and join the thoracic duct on the left side, and on the right the lymphatic duct of that side. Sometimes they open separately into the subclavian vein.

The glands of the axilla are frequently enlarged from sympathy with disease or inflammation of neighboring parts, and not infrequently run on to suppuration. They may be the subject of cancerous infiltration when the

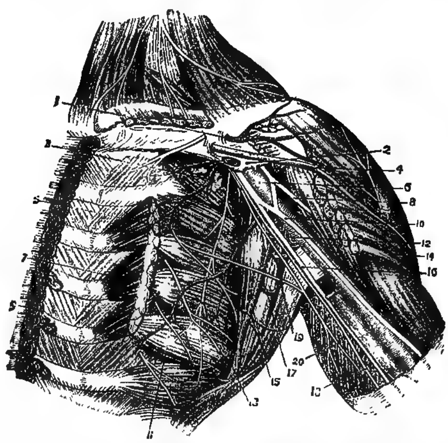


FIG. 374.—Brachial Plexus and Axillary Artery. 2, costo-coracoid membrane; 3, sup. thoracic and ulnar arteries; 5, long thoracic artery; 6, axillary artery; 8, musculo-cutaneous nerve; 10, median nerve; 15, subscapular artery; 16, ulnar nerve; 18, internal cutaneous nerve; 19, circumflex nerve; 20, nerve of Wrisberg, joined by intercosto-humeral.

breast is affected with malignant disease; occasionally, malignant disease first affects these glands. Scrofulous enlargement of the axillary glands is not uncommon, and their removal is sometimes called for.—Professor Verneuil (*Gazette des Hôp.*, October 10, 1879) recommends linear division of the pectoral muscles previous to excision of deeply-seated glands. As these glands lie chiefly along the vessels, there is great danger of hæmorrhage, and even if the main vein itself is not wounded, some of the large veins going to it may be easily nicked and give rise to free hæmorrhage.

In excision of the breast, when the axillary glands are affected they must always be removed, and this is often a difficult operation. The glands are very apt to become adherent to the vessels, especially the vein, which has often been wounded during removal of glandular tumors. When clearing the axilla of diseased glands the fingers will be found more serviceable than any cutting instrument, and infinitely safer. Abscess of the axilla, originating in the glands, is not uncommon, the glands most liable to suppurative inflammation being those under the edge of the great pectoral muscle. The course which pus takes when it forms in the axilla has already been described with the fascia. Strumous glands in the axilla frequently break down and suppurate, leaving sinuses which are very difficult to heal.

Supernumerary mammæ have been frequently reported as occurring in the axilla. Dr. Garland (*Edin. Med. Jour.*, 1877) reports cases where there were swellings in

the axilla during pregnancy and suckling; and Dr. Sharpe (*Med. Times and Gazette*, 1855) mentions a case in which a supplementary mamma, which enlarged greatly during pregnancy, occurred in each axilla, and milk could be squeezed out apparently through pores in the skin; there was no appearance of nipples.

Mr. Birkett (*Med. Times and Gazette*, vol. ii., 1868) describes several cases of cystic tumors occurring in early life in the axilla and extending into the neck. He strongly advocates excision in these cases.

Fatty tumors frequently develop in this region; they can be removed without much difficulty.

Francis J. Shepherd.

AZEDARACH, U. S. Ph., Pride of China (or of India); *Melia Azedarach* Linn.; Order *Meliaceæ*, is a fine, medium-sized, ornamental tree from India, but long cultivated in all the warmer parts of the world. It has delicate, twice pinnated leaves, fragrant clusters of lilac-colored flowers, and yellow fruits. Azedarach has been occasionally used for one or another purpose in various countries where it grows, and, in deference to a slight reputation in the Southern States, was some time ago admitted to the Pharmacopœia. It is now, however, excepting as an extemporary country medicine, entirely obsolete and not to be found in any market, North or South. The bark of the root is the officinal portion, and thus described: "In curved pieces or quills, varying in size and thickness; outer surface red-brown, with irregular, blackish, longitudinal ridges; inner surface whitish or brownish; longitudinally striate; fracture more or less fibrous; upon transverse section tangentially striate, with yellowish bast-fibres; almost inodorous, sweetish, afterward bitter and nauseous" (U. S. Ph.).

It contains a whitish-yellow resin, which is claimed to be the active principle.

Azedarach disturbs the digestive tract, causing, in large doses, vomiting and diarrhœa. It is suspected of being narcotic in still larger ones, but its qualities are not well known. Birds become stupefied by eating the berries. It is usually given, however, for intestinal worms, in decoction, or syrup of the fresh root. Dose, four to eight grams (ʒ j. ad ʒ ij.).

ALLIED PLANTS.—*Melia Indica* Brandis. *Margosa*, another Indian plant of the genus, has a bitter bark and wood. It is used as a tonic. There are no other plants of medical interest in the order.

ALLIED DRUGS.—For a list of anthelmintics, see KOOSSO.

W. P. Bolles.

AZORES. The Azores, or Western Islands, lie some eight hundred miles west of the coast of Portugal, between 36° 55′ and 39° 5′ N. Lat. and 25° and 31° 16′ W. Long. The islands, nine in number, are gathered into three minor groups, lying about one hundred miles apart, the general direction of the whole chain being from southeast to northwest. The largest island, that of Saõ Miguel, belonging to the southeastern sub-group, has a length of some forty miles, and is about ten miles broad; the average dimensions of the others may be estimated as about one-half as great as those just given. The whole system of islands is of volcanic origin, and their outlines are, in consequence, very picturesque, the shores being rocky and the central portion of each island rising in mountain peaks varying in height from 1,889 feet (island of Saõ Miguel) to 7,613 feet (island of Pico). Tropical and subtropical fruits are grown in the open air, and the climate is mild and very equable at all seasons of the year. A very close resemblance exists between the climate of the Azores and that of Madeira. The following figures, showing the mean temperature of the islands for the months of January, April, August, and October, and for the year, are taken from a table given on page 420 of Hann's "Handbuch der Klimatologie": Azores, Lat. 38° 8′ N.; Long. 26° 35′ W.; January, 56.8; April, 59.4; August, 71.6; October, 65.3; Year, 63.

The mean yearly extremes of temperature at Ponta Delgada (Saõ Miguel), and at Angra (Terceira), are stated by Dr. Hann to be as follows: Ponta Delgada, 80.4° F., highest, and 42.4° F., lowest temperature; Angra, 79.5° F., highest, and 44.0° F., lowest temperature.

The daily variation of temperature in the Azores is given by the same author as from 9° to 10.5° F.; the mean annual rainfall he puts at 35.4 inches, of which thirty-seven per cent. falls during the winter, twenty-nine per cent. during the autumn, twenty-three per cent. during the spring, and only eleven per cent. during the summer months.

The writer of the article on the Azores in the "Encyclopædia Britannica" describes the climate of the islands as follows:

"The climate is particularly temperate and equable, the extremes of sensible heat and cold being, however, increased by the humidity of the atmosphere. This is so great that paper-hangings will not adhere to the walls, and the veneering of furniture strips off. The range of the thermometer is from 45° F., the lowest known extreme, or 48° F., the ordinary lowest extreme of January, to 82° F., the ordinary, or 86° F., the highest known extreme of July, near the level of the sea. Between these two points (both taken in the shade) there is from month to month a pretty regular gradation of increase or decrease, amounting to somewhat less than four degrees (*Geographical Journal*, vol. xv.). In winter the prevailing winds are from the northwest, west, and south; while in summer the most frequent are the north, northeast, and east. The weather is often extremely stormy, and the winds from the west and southwest render the navigation of the coasts very dangerous."

Dr. Hermann Weber (in Ziemssen's "Handbuch der Allgemeinen Therapie," 1880) describes the climate of the Azores as somewhat cooler and less relaxing in its effect than that of Madeira. Of the accommodations for invalids provided in the islands at the time when his treatise on Climatotherapy was written, Dr. Weber does not speak in very high terms. ("Der Mangel an für Invaliden passender Accommodation ist jedoch für die nächste Zukunft ein Hinderniss zur klimatischen Benützung dieser Inseln.")

So similar, indeed so nearly identical, is the climate of the Azores with that of the more celebrated health resort of Madeira, that, for more accurate information respecting the benefits to an invalid likely to accrue from residence in these islands, the reader may be referred to the article concerning the latter place which will be found in a later volume of the HANDBOOK.

Huntington Richards.

BACK, DISEASES AND INJURIES OF. In wounds and injuries of the back, as in those of the chest and abdomen, we have to consider first, the injury inflicted upon the superficial tissues, and secondly, that sustained by the subjacent organs. The wounds of the superficial structures present no characteristics peculiar to this region. The back is, however, by reason of its numerous articulations, very liable to sprains. These may vary greatly in degree, and since it is impossible always to determine at the moment how serious the injury may have been, a sprain of the back should never be neglected, but should be watched and treated as though it were an important affair until its true nature is ascertained. The spinal ligaments may be simply strained, or they may be ruptured; or an injury of the back, which may at first seem of comparatively slight moment, may be accompanied with fracture or dislocation of a vertebra, with consequent compression or concussion of the cord; or compression may be caused by hæmorrhage within the canal. The location of the sprain may be indicated by a swelling, or there may be no external evidence whatever of injury. Sprains in the lumbar region are not infrequently followed by hæmaturia, but this symptom, although apparently so serious, is usually of little moment and disappears without any further complication. The treatment of simple sprains, without injury to the cord, is essentially rest in bed with, later, counter-irritation over the affected region.

Penetrating wounds of the back are serious because of the injury inflicted upon the internal organs. In determining what organs may have suffered in any particular

case, if we leave out of consideration for the moment the direct evidence afforded by the symptoms, it is necessary to ascertain the nature of the wounding object, whether a knife, a bullet, etc., and also the direction of the wound. If a knife or other sharp instrument have been used, it should, if possible, be ascertained how deeply it has penetrated, and whether the blow was struck from above, from below, or laterally; and if it be a gunshot wound, whether the weapon was discharged at close quarters, or whether the ball was nearly spent before penetrating the back. It must not be forgotten also that the course of a bullet is often very erratic, and that, while it has seemingly penetrated the abdominal or thoracic cavity, it may, in reality, have glanced along a rib and be lodged in the muscles on the other side of the back, or anteriorly. The position of the person at the time the injury was received is also to be considered, since, when he is in the recumbent position or when stooping, the liver and some of the other organs are higher than when the person is sitting or standing erect. And another point to be determined in certain cases is the time at which the wound was received, whether after a hearty meal or while the individual was fasting. Fig. 375 represents diagrammatically the ordinary position of the thoracic and abdominal viscera, but of course only in a very general way. For a description of the symptoms indicative of injury to particular organs, the reader is referred to the articles treating of these conditions under their appropriate headings (see also article on Wounds).

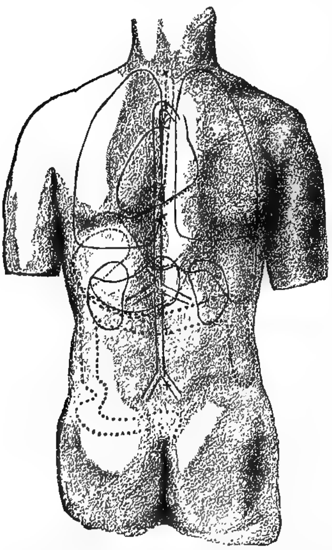


FIG. 375.—The Relations of the Thoracic and Abdominal Viscera, as seen from Behind. The outlines of the œsophagus, stomach, and large intestine are represented by heavy dotted lines; those of the liver and spleen by fine dotted lines; and those of the other organs by unbroken lines. The crosses indicate the location of the seventh cervical, fourth and ninth dorsal, and first, third, and fifth lumbar vertebræ. (Modified from Quain.)

The movements of the back are chiefly in an antero-posterior and lateral direction, though a slight amount of rotation is also possible. In the upper portion but little motion of any character takes place, and it is in the lumbar region chiefly that flexibility exists. A "stiff back" may be due to chronic rheumatic arthritis of the spine, to Pott's disease, to spinal anchylosis, to inflammation or rheumatism of the spinal or abdominal muscles, to psoitis, or to a sprain. Pain in the back is a common symptom, and may be due to any one of a variety of conditions, as *e.g.*, neurasthenia, muscular rheumatism, rachialgia, Pott's disease, nephritis, cystitis, renal or vesical calculi, an accumulation of gas in the intestines, uterine disease, myositis, or hysteria.

The back is frequently the seat of tumors and other swellings, the nature of which it is important, while at the same time not always easy, to determine. We have, in the first place, the ordinary fatty and fibrous tumors, nævi, epitheliomata, and sarcomatous and sebaceous tumors (the last two rarely), the diagnosis of which offers nothing peculiar in this region. Spina bifida, or hydrorachitis, is a not very uncommon affection, and is usually not difficult of diagnosis. A congenital cystic tumor lying on the spinal column, usually, though not invariably, in the lumbar region, becoming tense when the infant cries, and frequently varying in tenseness according to the position of the child, can scarcely be mistaken for any other affection. Except in cases in which the sac is enormously distended, the defect in the spinous processes can be detected on palpation. In certain cases of spina bifida there is paralysis of the lower extremities. Congenital tumors, either fatty or cystic, are occasionally met with over the sacrum, but they are unaccompanied with loss of substance of the bone and are situated, as a rule, below the ordinary seat of hydro-rachitic tumors. Abscesses of the back are by no means rare. They may be idiopathic, or the result of traumatism, or the pus from an empyema may point posteriorly. Abscesses may occur in this situation also in connection with caries of the ribs or Pott's disease, although this is not the usual course for the pus to take in the latter affection. It should not be forgotten that an abscess, pointing in the back or elsewhere, may be referable to spondylitis even though there be no angular curvature visible. The kyphos of Pott's disease can hardly be mistaken for anything else, but in lateral curvature with so-called rotation, the resulting prominence of the muscles on the side of the convexity may, if carelessly inspected, be taken for a tumor. The existence of a lateral deviation of the vertebral column in this instance should suffice to put the examiner on his guard. Sometimes this apparent tumor is at some distance from the spine, and is the expression of a secondary deformity and bulging of the ribs.

The back is the ordinary seat of bed-sores, whether occurring from pressure or of neurotic origin. There is no other condition with which bed-sores are liable to be confounded, though it is not always an easy matter to discriminate between the different varieties of this distressing affection (see article Bed-sores).

Diseases of the skin and muscles of the back do not differ in any essential points from similar affections in other parts of the body, and their consideration need not therefore be entered upon here. *Thomas L. Stedman.*

BACTERIA. The bacteria are low forms of life, comparatively speaking, whose ultimate structure and functions are as yet only imperfectly known. They may be defined, from the morphological point of view, as extremely minute fungi; individual bacteria being, without exception, invisible to the naked eye. They are often composed of but a single cell, and they never exhibit highly differentiated organs or tissues. In short, they appear to consist of but little more than a speck of living protoplasm which has surrounded itself with a delicate layer, or wall, of cellulose. From the physiological point of view, however, they are of absorbing interest. This is not merely because of their connection, in some cases established, with certain (zymotic) forms of disease, nor even on account of the probability that they have more to do than is generally supposed with the public and private health. To the physiologist, their prodigious powers of growth and reproduction; their astonishingly rapid alterations of the media (or environments) in which they multiply, and the occult and subtle chemistry which they employ—these, and other mysterious facts of their life-history, are sources of profound concern.

It is well established that bacteria are the producers of numerous fermentations and putrefactions; such, for example, as the souring of milk, or the lactic fermentation, the ammoniacal fermentation of urine, the so-called butyric fermentation, the spoiling of meat, fish, and other highly nitrogenous foods, and, indeed, of putrefactions in general (see Fermentation). The theory has also been propounded, and is partially established, that bacteria are in some cases dangerous parasites and producers of disease; living within the organism, and setting up there veritable fermentations, or diseases, at its expense. In this way it is supposed that disastrous effects are brought about: either by the mere presence of these essentially foreign bodies, or by their theft of foods needed by the subject of their attack, or by actual poisoning, due to poisonous compounds (ptomaines) either excreted or incidentally liberated, during their active period (see Germ Theory).

The term "bacteria" has become somewhat unfitted for the whole group of organisms under discussion, because it belongs really to a single genus only. An attempt

has been made to introduce the word "microbe" (signifying a little living thing) to take its place as a general term, and this has, apparently, found great favor with the public. It has the advantage and the disadvantage that it does not commit the user of it to any exact idea whatsoever as to the nature of these organisms. We are perfectly justified, however, in retaining the word bacteria; especially since De Bary has employed it very lately in the title of an exact botanical treatise.

For the morphology and classification of bacteria see Schizomycetes. For a further account of their physiology see Fermentation and Germ Theory. Consult Sternberg, "Bacteria," Wood, 1884, for a good general account of the whole subject. *William T. Sedgwick.*

BAEL FRUIT (*Belæ Fructus*, Br. Ph.; *Ægle Marmelos* Correa, Order *Rutaceæ*). The botanical source of the above fruit is a good-sized tree, attaining to the height of ten or twelve metres (30 or 40 feet). It has ternate, fragrant leaves, which, like those of the family in general, are dotted with translucent glands, and it is usually armed with long, sharp thorns. The flowers are large and white, something like those of the orange. The fruit is also, in general structure, like an orange, but has a hard and brittle, instead of a leathery rind. The tree is a native of India, where it is found wild nearly everywhere, besides being extensively cultivated, especially in the vicinity of temples. The cultivated varieties produce larger and more agreeable fruits than the wild, which have, from time immemorial, been used in Asia as a preserve or delicacy. All parts of the tree have been employed by the native doctors as medicine.

For medicinal use the fruit should be collected green, and dried; such specimens are usually sliced or quartered; but it is fully as frequently gathered quite ripe, and broken in an irregular manner, instead of sliced. The fragments are evidently of a fruit about as large as an orange, with a hard, gray, bone-like shell, about two millimetres thick, enclosing an originally soft, but now shrunken and hard, dull, orange-red, pulp. This is divided by from eight to fifteen partitions, and contains a few woolly seeds in each division. When fresh, the fruit is fragrant from oil contained in a few cells in the outside of the rind; and it has an agreeable, juicy pulp. In the dried specimens both these qualities have disappeared, and a mild, sourish, mucilaginous taste only, is left.

There is nothing of note in its chemical composition but mucilage and ordinary plant matters; neither is there much to say for its medicinal qualities. It is usually given for diarrhœas. The dose is large and indefinite. An infusion extracts all its qualities.

ALLIED PLANTS.—See RUE.

ALLIED MEDICINES.—One or two other fruits are now and then sold as bael. A botanical examination of these will easily discover the substitution.

The medicinal qualities of bael are not distinct enough for special comparison. *W. P. Bolles.*

BAHAMAS. For an account of the climate, climatotherapy, etc., of the Bahama Islands, see the article on Nassau.

BAILEY SPRINGS. *Location and Post Office*, Bailey Springs, Lauderdale County, Ala.

Access, by Memphis & Charleston Railroad to Florence, thence by carriage to springs, nine miles distant.

There are seven different springs, issuing from a ledge of flint rock, and known as the Rock, Brick, Soda, Alum, Iron, Sulphur, and Freestone. The following is the qualitative composition of the three principal ones:

ANALYSIS.

Rock.	*Brick*, or *Chalybeate.*	*Sulphur.*
Magnesia.	CO_2.	Magnesia.
Calcium.	Sulphuretted hydrogen gas.	Calcium.
Sodium.	Carbonate soda.	Sulphur peroxide.
Chlorine.	Carbonate magnesia.	Chlorine.
Sulphur peroxide.	Carbonate potash.	Iron.
Silica.	Chloride sodium.	Silica.
Potassium.	Oxide iron.	Sodium.
CO_2.		Carbonic acid.
Ammonia—a trace.		Ammonia.
		Albuminoid.

THERAPEUTIC PROPERTIES.—The "Rock," which is most used, and on whose curative qualities the fame of these springs is based, is diuretic, alterative, and tonic. It is said to be eminently beneficial in diseases of the kidneys and bladder, and in scrofulous affections and various forms of dyspepsia arising from insufficient secretion. The springs are situated in a little valley on an elevated plateau, at the base of a semi-circular hill, three hundred feet above the nearest watercourse, the highest ground in the surrounding country. The climate is that of the mountainous region of North Alabama, the thermometer rarely reaching 90° F. in the hottest weather, while the nights are cool enough to make the use of a blanket very agreeable. The average annual rainfall is about thirty inches. The ordinary drinking-water of the country is a tasteless limestone. The hotel buildings are old-fashioned structures, with large rooms, and plenty of windows, doors, and verandahs. They are situated on the summit of the hill, above the springs, with extensive grounds turfed with grass, and shaded with large trees. The location of the hotel should insure perfect drainage. About a fourth of a mile away, Shoal Creek, a beautiful stream, rippling over a bed of solid rock, forming here and there deep pools where black bass love to linger, furnishes sport and amusement for those fond of fishing and boating.

G. B. F.

BALM (*Melissa*, U. S. Ph.; *Folia Melissæ*, Ph. G.; *Mélisse officinale, Citronelle*, Codex Med.). *Melissa officinalis* Linn., Order, *Labiatæ*, is a perennial herb, from one-half to one metre in height (20 to 40 inches), with several branching leafy stems. The leaves are opposite, rather large, ovate or oblong, deeply toothed, and, as well as the stem, hairy and glandular. The flowers are white, in clusters, in the axils of the upper leaves, and have the following characters: calyx narrowly bell-shaped, thirteen-nerved, and two-lipped; the upper lip two-, and the lower one three-lobed; lobes short and broad. The corolla tube is longer than the calyx, slightly inflated in its upper half, bent or curved upward; the limb of the corolla is two-lipped, both lips flattish, the upper notched at the apex, the lower broad, and deeply three-lobed. There are four stamens with diverging anthers, the two lower longer than the others; all ascending under the upper lip. The ovary consists of four one-seeded lobes.

FIG. 376.—Balm. Plant in flower reduced and flower enlarged. (Crié.)

The plant is a native of Southern Europe, and is frequently cultivated in Europe for the sake of its oil. It is now and then met with in American gardens.

The officinal portion consists of the leaves and tops, which should be gathered at the time of flowering. The botanical description, given above, will serve for that of the drug, which, it may be remarked, loses very much of its fragrance in drying. Its principal constituent is the agreeable Oil of Balm, *Oleum Melissæ* (not to be confounded with the East Indian Oil of Citronelle, which resembles it), of which it contains a small percentage (one-eighth to one-fourth per cent. (U. S. Dispensatory.)

USES.—Melissa has, in sufficient doses, the stimulant properties of the order, but, as usually used, is scarcely more than a flavor. An infusion of the herb can be given *ad libitum*, and when taken hot and in large quantity, like other mints, with the aid of hot water and plenty of coverings, is sudorific. The dose of the oil is from one to three decigrammes (♏jss. ad ♏v.).

ALLIED PLANTS.—There are but two or three species

in the genus, and these are not important. *Calamintha officinalis* Moench.; *Calament*, of the Codex Med., is sometimes included in it (*Melissa Calamintha* Linn.); it has similar properties. For the Order Labiatæ, see PEPPERMINT.

ALLIED DRUGS.—See PEPPERMINT, also ANISE, and other fragrant substances. *W. P. Bolles.*

BALNEOTHERAPEUTICS. Under this head we may consider: 1, the action of cold, warm, and hot water, steam baths, douches, frictions, and drinking; 2, the effects produced by drinking or inhaling water containing various substances; 3, the mental influence resulting from change in habits, diet, air, occupation, and amount of exercise taken while at the baths. The use of baths as a therapeutic agent should be combined with diet, exercise, etc., and they may be tried at home if the thing be done in a systematic manner. As a rule, however, a course of balneotherapeutics can be taken far more advantageously at some institution, especially if it is located in a region which possesses good climatic conditions.

"Our present knowledge is insufficient to form a satisfactory theory of the mode of action of mineral waters in various pathological states. The present condition of balneotherapeutics is empirical, and rests on observation and experience" (Leichtenstern).

The effects of mineral baths depend on: 1, temperature; 2, amount; 3, constituents, such as salts and gas.

So far as the body temperature is concerned it will make no material difference whether the bath be one of ordinary water or one containing special medicinal properties, provided they are both of the same temperature.

After the bath there may be a continuation of the effect from evaporation of the water left on the skin or imbibed by it. All investigations show that while there is decided abstraction of warmth, if the temperature and duration of the bath do not pass a certain point, the temperature of the interior of the body rises. But the internal temperature falls if the water have a temperature as low as from 20° to 24° C. (68° to 75° F.), and the bath be continued fifteen to twenty-five minutes.

After a moderate bath, which has not immediately affected the temperature, this falls for a time (primary after-effect), then rises somewhat (secondary after-effect).

Local abstraction of heat by douches, half baths, etc., also tends to increase the internal temperature of the body.

In cold baths the loss of heat in healthy persons is considerable, and is proportional to the differences of temperature. An ordinary-sized man, remaining for fifteen to twenty-five minutes in a bath of 34° C. (93.2° F.), loses a normal amount of heat (ninety-two calorics in an hour); at 30° (86° F.), double this; at 25° (77° F.), threefold; at 20° (68° F.), more than fivefold (Liebermeister).

Constancy of bodily temperature in cold baths depends on regulation of loss of heat and on its production; the latter is increased two or threefold. Loss of heat is due to contraction of the cutaneous capillaries from irritation of the nerves by the cold. Irritation of these nerves is propagated to the pores and medulla and heat-producing centres. In animals, according to Röhring, energetic irritation of the skin causes increased internal temperature by increased capillary circulation; still more active irritants cause contraction to follow the temporary dilatation and so reduce temperature. Liebermeister thinks the muscles are the organs in which the temperature increases.

In an adult, if the heat be retained in the body (by warm baths), the temperature increases nearly 1° C. (1.8° F.) every half-hour. Bartels found that in a steam bath of 51° C. (123.8° F.), the temperature rose in eight minutes from 38° to 39.8° C. (100.4° to 103.5° F.), and in thirty minutes to 41.6° (107° F.); there was a corresponding reduction subsequently.

The impression that "tissue metamorphosis" is decidedly influenced by various mineral baths is very general, but rests on no exact observations; the changes may be due to concomitant influences. Cool baths, sponging, and exposure of the body increase the excretion of carbonic acid, and also its formation, in proportion to the loss of heat and its production. If long continued, so as to reduce internal temperature, these cooling measures will effect a reduction of carbonic acid and of consumption of O. In hot baths (increasing temperature) the tissue changes are increased. Increased decomposition of non-nitrogenous substances is caused by cold baths, mostly in muscles.

Irritation of the cutaneous nerves by the salts and gas contained in ordinary mineral waters is usually too slight to induce transformation of fat or to increase the carbonates, as is done by cold. In cold baths, if the temperature be not decidedly lowered, the decomposition of albumen, *i.e.*, the excretion of urea, is not changed; but hot baths increase the excretion of urea, *i.e.*, the decomposition of nitrogenous parts of the body. It is not probable that these results are affected by the mineral or gaseous contents of the water used. But if they act thus on a healthy body, will they do the same in disease? It is probable that such is their action.

To get rid of fat, cold or hot baths should be supplemented by exercise, diet, mineral waters containing chloride of sodium (to increase destruction of albumen), and drinking plenty of water.

During the bath, perspiration of the parts under water is said to be arrested, whereby twenty-five grammes per hour of water would be retained in the body; this might be passed by the kidneys or lungs. Evaporation of this twenty-five grammes would have abstracted 14.5 calorics, but the bath removes ninety-two in the course of one hour. After the bath there is increased evaporation. Half an hour in a steam bath may carry off from five hundred to eight hundred grammes of sweat; if this be favored by bed-covering, in two to three hours the loss may amount to from three to five pounds.

In the bath the excretion of carbonates from the skin continues, while the evaporation of the submerged parts is arrested, but after the bath both are increased.

Just after a bath the amount of urine is often temporarily increased, but the amount for twenty-four hours is not changed; but the urine passed is more concentrated, the specific gravity of that which is voided during the period of increased secretion is less after cold, but higher after hot, baths. Sweat baths cause less diuresis. Ordinary and mineral baths have about the same effect. Aside from the increased excretion of urea induced by baths which elevate the temperature, no effect has certainly been recognized on the amounts of the individual constituents of the urine excreted.

In the cold bath there is decided contraction of the cutaneous vessels. This is most marked at first, and gradually diminishes.

Baths above blood heat induce dilatation of the cutaneous vessels, as shown by redness and turgescence. This may continue some hours.

Vascular dilatation, which is secondary in cold, and primary in warm, baths, seems to be increased by salts and gas in the water.

Most observers assert that cold baths retard heart-action.

In baths of blood heat which elevate the bodily temperature, also in hot and vapor baths, the frequency of the pulse is increased in proportion to that of the bodily temperature. Tepid baths have little influence on the pulse, unless they contain salts or gas, in which case they may cause hyperæmia of the skin. Contraction of cutaneous capillaries increases blood-pressure in the arteries; this reacts on the left ventricle to increase the number and strength of the heart-contractions.

It is undetermined whether gaseous or salty contents of mineral waters cause sufficient cutaneous irritation to induce reflex excitement of the vaso-motor centres and vagus. The contraction of the peripheral vessels in cold, and their dilatation in hot, baths, of course changes the circulation in the body; with the internal vessels it is the reverse.

Observations show that in the cold bath respiration is increased by deeper or by more frequent inspirations. This is probably due to consumption of oxygen in the tissues. There is no change in frequency of respiration in tepid baths. In hot water and steam baths the increase corresponds to that of the bodily temperature and car-

bonic acid. Respiratory movements are not influenced by salts and gas in mineral waters.

The action of cold and warm baths is manifested by their effects on certain general conditions and on the cerebral activity. Brief cold baths, douches, etc., are refreshing, and urge to muscular movements. Prolonged warm baths, hot, or vapor baths, usually relax and make sleepy. The exciting or depressing effect of cold or warm baths on the cerebral activity may be sought in reflex influence upon the cerebral vessels by thermic irritation of the sensitive nerves. Warm baths may lessen or arrest reflex spasm of voluntary or involuntary muscles. Tepid baths diminish the excitability of the peripheral ends of the sensitive nerves, and thus that of the nerve-centres. After either warm or cold baths there is a stage of coolness, which is best relieved, after cool baths, by physical exercise; after warm baths, by rest and more covering. This may be due to increased evaporation.

Irritation of the sensitive nerves from cold bath often causes reflex movements, such as evacuation of bowels or bladder in typhoid patients.

Probably, through the nervous system, baths have other unknown influences on the organism, producing changes in the secretions of saliva, gastric and intestinal juices, absorptions from intestinal canal, etc.

Heymann and Krebs found that the electrical condition depended, 1, on the gas in water; 2, temperature (conduction increased by raising, reduced by lowering); 3, salts. Gas causes an electro-positive (except SH_2), neutral or basic salts an electro-negative condition, as compared with distilled water.

By the mechanical action of baths is meant the effects of their mass and weight; these would be increased by motion, as of waves, of running water, frictions, douches, etc.

The question as to the absorption of constituents of baths by the skin has caused much discussion, the affirmative being vigorously maintained by proprietors of mineral baths. But, according to Leichtenstern (in Ziemssen's "Allgemeine Therapie"), experiments by weighing indicate that there is little imbibition by the skin; water and salts impregnate the superficial layer, but do not go deep, and what has entered the skin is probably evaporated soon after the bath. The palms of the hands and soles of the feet are peculiarly suited to imbibition, having no sebaceous follicles. In the case of washerwomen, imbibition would be further favored by long exposure, friction, and soap.

The amount of urine is increased after bathing, but only temporarily, and probably from suppression of perspiration; possibly also to a slight degree from excitement of cutaneous nerves. If such be the case, there should be a more marked increase of the amount of urine secreted after bathing in waters containing mineral and gaseous constituents; but analysis has shown no increase in the amount of iodide of potash, iron, or chloride of sodium, from bathing in waters containing large amounts of these substances, if care has been taken to prevent absorption by the mucous membranes.

Experiments made by applying compresses wet with watery solutions of opium, morphine, atropine, digitalis, etc., were negative; contrary results are ascribed to inexactness (contact of the waters with mucous membranes, inhalation, etc.).

It seems to make some difference if the solutions be rubbed in; and solutions in ether, alcohol, or oils are better absorbed; gases are absorbed.

Balneotherapeutics may properly consider the effect of the water drunk; the body being composed of fifty-nine per cent. of water, part of which is daily lost, this waste must be supplied.

One effect of cold drinks is reduction of bodily temperature and pulse, and increased blood-pressure; possibly from cold water in the stomach exciting the vasomotor centres. Probably the water is mostly absorbed in the stomach; cold water drunk fasting soon leaves the stomach, entering the veins; but an increased proportion of water in the blood is not induced for any considerable time.

Copious water-drinking is a means for washing out the organism, and it causes temporarily an increased excretion of certain products of decomposition; the free diuresis is due to excretion of urea, salt, phosphoric and sulphuric acids, while the amount of uric acid excreted is diminished.

Undoubtedly many drink cures owe their effect more to the cleansing, diuretic effect of the increased amount of water drunk, than to the salts or gas in the waters; they are useful for causing absorption of exudations, urates, bile, poisons. For this purpose pure water, slightly warmed, is best. The excretion of water from the skin and also from the bowels is increased, if the water be *cold.*

Although elaborate analyses are given of mineral springs, it is probable that their effects are due to one or a very few constituents, and to the temperature at which the water is used, as well as to the surroundings.

Indifferent thermic waters (Wildbad), which have a temperature of from 25° to 67° C. (77° to 152° F.), contain only a small quantity of salts or gas; they are useful against the remains of chronic inflammation, chronic rheumatism of the joints and muscles, contractions, false anchyloses, chronic skin diseases, chronic exudations in the pleura and peritoneum, old paralyses, catarrh of the bladder and pelvis, of the kidney, and old syphilitic lesions which have been treated by mercury.

Leichtenstern's Table I. gives the following list of indifferent thermal springs: Badenweiler, Bath, Bormio, Gastein, Johannisbad, Landeck, Leuk, Liebenzell, Mont Dore, Neuhaus, Plombières, Pfäffers and Ragatz, Römerbad, Schlangenbad, Teplitz, Tüffer, Tobelbad, Warmbrunn, and Wildbad.

Simple Acid Springs.—With the exception of carbonic acid, the constituents of these springs are too slight in amount to have much effect.

The carbonic acid gives a pleasant sensation in the mouth; in the stomach it gently irritates, exciting appetite and digestion. If respiration be good there is no accumulation of CO_2 in the blood, or there would be an increase of carbonates in the urine. It is a more speedy diuretic than ordinary water, possibly because CO_2 facilitates absorption of water; also alcoholics containing CO_2 more quickly intoxicate.

Carbonated waters do not affect respiration, pulse, or blood-pressure with certainty; they are refreshing—good in dyspepsia and for sluggish bowels.

In baths their action is not specific, but is due to irritation of the skin; the CO_2 probably enters the skin to some extent. Baths may be given in CO_2, the head being in free air, or by gas douches, for hyperæsthesias, neuralgias, prurigo, etc.

Leichtenstern's Table II. gives the following springs, containing carbonic acid: Apollinaris, Brückenau, Charlottenbrunn, Cudowa, Dorotheenquelle, Carlsbad, Fideris, Flinsberg, Gleichenberg, Heppinger, Imnau, Landskroner, Liebwerda, Marienbad, Nauheimer, Neuenahr, Niedernau, Passug, Reinerz, Rippoldsau, Schwalbach, Sinzig, Tarasp, Teinach, and Wildungen.

Alkaline Springs are those containing more or less carbonate of soda and free carbonic acid. They are divided by the Germans into, 1, alkaline; 2, alkaline muriatic, and, 3, alkaline saline waters.

Carbonate of soda reaching the stomach is broken up into chloride of sodium, and also lactic, butyric, and acetic acids, with free carbonic acid. As digestion does not occur if the gastric juice is neutral or alkaline, copious drinking of water containing soda, during or near meal time, is injurious. If there be too much acidity, a slight amount of such water may be taken. If the food be exclusively amylaceous, a saline condition of gastric juice favors the transformation of starch, begun in the mouth, to dextrin and sugar.

Cold soda waters, especially the saline, excite gastric peristalsis, from the presence of either carbonate of soda or free carbonic acid. They are useful in chronic gastric catarrh, particularly where quantities of tough mucus are formed and vomited, when they may be drunk on an empty stomach. They should not be used in dilated stomach, as the carbonic acid would still further distend

it; or where there is deficiency of acid, as in dyspepsia, anæmia, fever, or convalescence.

Chronic intestinal catarrh, due to over-acidity of the chyme, is favorably affected by soda waters, especially the saline; the same is true of certain hepatic affections (cirrhosis, congestion of liver, fatty liver, etc.), which cause chronic intestinal catarrh.

The benefit of soda waters in catarrhal icterus is chiefly due to their beneficial effect on duodenal catarrh. How it acts in getting rid of gall-stones is uncertain. It is doubtful whether we can *much* affect the alkalinity of the blood by alkaline waters.

The reduction of fat at Marienbad, etc., is, perhaps, not so much due to the soda in the water as to the strict diet, forbidding alcohol and amylaceous foods, to the systematic exercise, and to the laxative effect of the water.

Carbonate and sulphate of soda have been credited with specific effects in *diabetes*, on the supposition that lack of alkali in the blood prevented complete combustion of the sugar. Perhaps the benefit obtained, by patients suffering from this disease, at Vichy and Carlsbad may be also ascribed to diet and surroundings. Freely drinking distilled water increases the excretion of sugar.

There is some difference of opinion as to the effect of alkaline bicarbonates in oxaluria; but not in vesical catarrh, gout, uric acid diathesis, renal and vesical calculi. While uric acid calculi are acted on by alkaline waters, under their use there is a tendency to deposit of earthy phosphates, and most urinary calculi have a nucleus of urates, and externally are composed of phosphates or oxalate of lime. While uric acid calculi require waters rich in alkalies, but poor in carbonic acid, those composed of phosphate and carbonate of lime demand increased acidity of urine or more carbonic acid.

If *gout* be due to an overloading of the blood and tissues with urates, the use of the carbonates of the alkalies, combined with drinking plenty of water, may benefit it.

Soda waters that are warm or have been warmed by milk or whey, are used in catarrhs of the air-passages and throat.

As *baths* these waters act as do other warm baths, especially such as contain carbonic acid. It is doubtful if the amount of *lithium* in any of these waters is sufficient to influence their action in any way.

Leichtenstern's Table III. gives the following list of *alkaline* springs: Rohitsch, Vals, Passug, Vichy, Radein, Fellathalquellen, Bilin, Fachingen, Preblau, Obersalzbrunn, Johannisquelle, Lipik, Giesshübel, Apollinaris, Geilnau, and Neuenahr.

Alkaline muriatic: Szczawnica, Luhatschowitz, Gleichenberg, Tonnistein, Ems, Weilbacher, Royat, Selters, Roisdorf. These contain bicarbonate and chloride of sodium, with free carbonic acid.

Alkaline saline: Bertrich, Elster, Franzensbad, Fuered, Karlsbad, Marienbad, Rohitsch, Tarasp. These mostly contain sulphate, bicarbonate, and chloride of sodium, with free carbonic acid.

Bitter Waters naturally come next in order, as, besides their chief constituent, sulphate of magnesia, they also contain sulphate of soda, and their therapeutic indications are the same. The most important of their effects is the purgative. Sulphate of magnesia parts with some of its acid to soda and potash in the intestines. The purgative action is due to its increasing peristalsis and intestinal secretion; there is not much effect on the liver. After long use they lose their effect somewhat; in some cases they are not well borne, as in anæmic, convalescent, or tuberculous patients; but in chronic intestinal catarrh, habitual constipation of hypochondriacs, or sedentary persons, their prolonged use is often beneficial. Sulphate of magnesia increases the decomposition of albumen. Mosler, under the daily use of two hundred and fifty grammes of bitter water, found an increase of six per cent. of urea.

Leichtenstern's Table IV. gives the following list of bitter waters: Birmenstorff, Friedrichshall, Franz-Joseph Bitterquelle, Galthofer, Grossenlüder, Hunyadi-Janos, Ivanda, Kis-Czég, Kissingen, Mergentheim, Montmirail, Ober Alap, Püllna, Saidschütz, Sedlitz, and Unter Alap.

Chloride of Sodium waters contain, besides this constituent, other chlorides, sometimes also iodine and bromine, carbonic acid, or iron. The percentage of chloride of sodium may vary from one to twenty-five; the weaker waters are used internally, the stronger for baths; these strong waters are called "Soolquellen."

Chloride of sodium increases the gastric juice, and is useful in anorexia, dyspepsia, etc.; it also excites peristalsis of the stomach, where it is mostly absorbed; but if it passes to the intestines its effect there is similar. It is slightly diuretic, and if given freely it increases the nitrogenous constituents of the urine. It is supposed to favor tissue change, and to be useful in chronic uterine troubles, pelvic exudations, peri- and para-metritis, etc.

Voit claims that chloride of sodium influences the solution and diffusion of albumen. Waters containing it benefit catarrhs of the respiratory organs and chronic pharyngeal catarrh; in this, as in other mineral waters, much of the effect may be due to the water alone, and not to its special mineral constituents; the same is true of those waters containing small amounts of bromine and iodine. Chloride of sodium baths range from one to ten per cent. solutions; they usually have a strength of from two to three per cent. They cause cutaneous irritation, some diuresis, increased transformation of albumen, with a daily increase of one or two grammes in the urea; there is also diminution of uric acid and the phosphates. Excretion of carbonic acid and absorption of oxygen are increased.

These baths act favorably in scrofula, rickets, chronic exudations and inflammatory residua, chronic metritis, etc., perhaps by producing cutaneous irritation and thereby exciting tissue change. These, as other warm baths, are efficacious in dry chronic exanthemata; not so, however, in eczemas, especially if moist.

For making salt-water baths at home we may use rock-salt. There are concentrated solutions, prepared from some of the German springs, by boiling down the water; these may be added to ordinary warm water for baths. Where this water is evaporated, or in rooms where it is nebulized, patients may breathe the vapor or spray for bronchial catarrhs, etc.

Leichtenstern's Table V. gives the following list of saline springs:

A. *Weak Chloride of Sodium Waters* (containing less than 1.5 per cent.).—(*a*) Cold springs: Arnstadt, Also-Sebes, Cannstadt, Dürkheim, Hall, Heilbronn, Homburg, Iwonicz, Königsdorff-Jastrzemb, Kissengen, Krankenheil, Kreuznach, Kronthal, Mergentheim, Münster, Nauheim, Neuhaus, Neu-Rakoczy, Pyrmont, Rehme, Salzhausen, Salzschlirf, Schmalkalden, Soden, Sodenthal, Sulzbad, Sulzbrunn, Wiesbaden, Wildegg.

(*b*) Warm springs: Baden-Baden, Battaglia, Bourbonne les Bains, Burtscheid, Mondorf, Soden, Wiesbaden.

B. *Stronger Salt Springs*—(*a*) Cold waters: Aussee, Arnstadt, Aibling, Bex, Frankenhausen, Gmunden, Hall, Ischl, Jaxtfeld, Juliushall, Köstritz, Nenndorf, Rheinfelden, Reichenhall, Rosenheim, Rothenfelde, Salzungen, Stotternheim, Sulza, Traunstein, Artern, Baassen, Castrocaro, Colberg, Elmen, Goczalkowitz, Grossenlüder, Hall, Hubertusbad, Königsberg, Kösen, Nauheim, Oldesloe, Orb, Pyrmont, Salzdetfurth, Salzuflen, Suderode, and Wittekind.

(*b*) Warm waters: Nauheim, Rehme-Oeynhausen, Salzburg.

Sea Baths.—In these the chief factors are the cold bath, the salt water, and the motion; also the effect of the climate and changed mode of life. They cause contraction of the cutaneous capillaries, and reduction of the peripheral, and elevation of the internal, temperature; hence they are unsuited for patients with tendency to internal hæmorrhage or heart disease. Part of this increased internal temperature must be due to increased production of heat, which is accompanied by increased excretion of carbonic acid and absorption of oxygen. Consumption of fat is another effect of sea baths; hence thin persons, convalescents, anæmic persons, etc., may be harmed by them or by other cold baths; but they may be benefited by warm baths of sea water.

Balneotherapeutics.

Sea baths are usually taken at about 21° C. (70° F.). They have a reputation in scrofula, especially in fatty subjects, in hypochondriasis, neurasthenia, etc., and as a "hardening" process in persons who take cold easily; the evenness of the temperature on the coast is also beneficial in such cases. The moisture in the air retards excretion of water by the skin and lungs, and consequently increases the quantity of urine and the tissue changes. Generally the appetite is improved and weight increased, in spite of the baths. The proportion of salt in the water out at sea is much the same at different places, but along the coast it depends on the amount of fresh water poured in from rivers and smaller streams. In a quart of sea water there are about thirty grammes (1 ounce) of solids; mostly chloride of sodium, with some chloride and sulphate of magnesium, and sulphate of lime.

Iron Springs usually contain the metal as a bicarbonate, rarely as a sulphate, and the proportion is small (from 0.03 to 0.1 gramme to a quart); they also contain carbonic acid, and they are always cold springs. The entire amount of iron in the blood of an adult is stated as about 3.0 grammes. Drinking a quart of iron water daily would supply about four centigrammes of iron; so probably much of the benefit derived at iron springs is from surroundings, etc. The iron taken into the system is passed off mostly by the fæces, not by the urine. Iron is probably not absorbed through the skin, and baths of iron waters act only as other baths would.

Leichtenstern's Table VII. gives the following list of iron springs: Alexisbad, Antogast, Althaide, Berka, Bocklet, Charbonnière, Cudowa, Driburg, Elöpatak, Elster, Franzensbad, Flinsberg, Freiersbach, Griesbach, Gonten, Godesberg, Homburg, Imnau, Krynica, Königswart, Lobenstein, Liebenstein, Liebwerda, Malmedy, Muskau, Niederlangenau, Pyrmont, Petersthal, Pyrawarth, Polzin, Rippoldsau, Reiboldsgrün, Ronneburg, Reinerz, Steben, Spaa, St. Moritz, Soultzbach, Sternberg, Szliacs, Sangerberg, Schwalbach, Tarasp.

Sulphur Springs.—These contain but little sulphur, which is in the shape of sulphuretted hydrogen, or sulphurets of metals; nor do they contain much of solids of any kind, though they are occasionally named from some other constituent, as chloride of sodium, lime salts, etc. Hence we may suspect that their effects are at least partly due to attention to bathing and to drinking the *water*, as well as to air, diet, etc.

Sulphur waters have great reputation in chronic poisoning by mercury and lead, where it is supposed to convert the mercury into sulphuret, which is dissolved by alkaline carbonates and passed off by the urine, while the lead is changed to insoluble sulphuret and remains innocuous. In acute lead poisoning, sulphur springs containing soda or magnesia would add a purgative to an antidote. It is a question if part of the effect of sulphur waters in such cases is not due to increased decomposition of albumen and albuminate of lead, induced by the copious water-drinking, supported by the baths.

Syphilis is also treated with asserted success by sulphur waters; and chronic cases are certainly benefited, but might be so by simple water. Chronic skin diseases are also treated by these waters, more especially since the recognition of the parasitic origin of scabies, favus, herpes tonsurans, pityriasis versicolor, etc.

It is claimed, perhaps on insufficient grounds, that sulphur increases the secretion of the gastric, pancreatic, and intestinal juices.

The sulphur taken into the blood escapes through the lungs and skin, and through the kidneys as sulphates of potash or soda.

Sulphur waters may be advised where sulphur is indicated in addition to warm baths and drinking freely of water, as in chronic rheumatic and articular affections, poisoning by metals, syphilis, chronic skin diseases, paralyses, etc.

Leichtenstern's Table VIII. gives the following list of sulphur springs:

(*a*) Warm springs: Aachen, Aix les Bains, Baden in Aargau, Baden near Vienna, Landeck, Lavey, Schinznach, and various springs in the Pyrenees and Hungary.

(*b*) Cold springs: Alveneu, Eilsen, Gurnigel, Höhenstedt, Kreuth, Langenbrcüken, Meinberg, Nenndorf, Sebastiansweiler, Stachelberg, Weilbach, and Wipfeld.

The latter (*b*) generally contain much more sulphuretted hydrogen than the former.

Earthy or Calcareous Mineral Waters.—Besides carbonic acid and sulphate of lime or magnesia, these springs contain no considerable quantity of other salts; many lime springs supply ordinary drinking water, called "hard" water. Solid foods contain more lime than is required by the body; and the question is, perhaps, not so much to supply this article, as to have it taken up by the system; and possibly this may be more readily done from waters holding it in solution; but probably the "water cure" furnishes the chief advantages in the treatment by these waters.

Rachitis is the disease principally supposed to be benefited by lime waters; they are also given as antacids in gastric catarrh with excessive acidity, and as astringents in diarrhœa and chronic catarrh of the urinary passages and bronchi. When, with catarrh of the bladder or kidneys, there is a suspicion of calculus, lime waters should be avoided. In limestone regions calculi are of particularly frequent occurrence.

At some of the calcareous springs in Germany there are rooms for converting the waters into spray for inhalation. It seems as if most of the benefit from this would come from the moisture and the deeper inspirations required.

Leichtenstern's Table IX. gives the following earthy mineral springs: Driburg, Contrexéville, Inselbad, Leuk, Lippspringe, Weissenburg, Wildungen.

Bog and Mud Baths.—The bog earth used at various places for baths is found especially at iron and sulphur springs; it is generated by the decomposition of plants in the presence of water; various mineral deposits also contributing to its formation. This bog earth being mixed with warm water, its salts are dissolved out, and the insoluble part mixes into a pulpy or soupy consistence. Baths composed of this mud-like material act in precisely the same manner as do warm or hot baths containing various cutaneous irritants, and are useful in hastening absorption of chronic exudations and indurations in the pelvis, uterus, etc., and in neuralgias, peripheral paralyses, contractions, anchyloses, and skin diseases. Bog cataplasms are used for the same purposes as ordinary cataplasms.

Mud baths are made from the deposits, in the beds of streams or springs, of the remains of low plants and animal organisms.

Among these bog and mud baths are Bocklet, Brückenau, Driburg, Elster, Eilsen, Franzensbad, Marienbad, Nenndorf, Pyrmont, Reinerz, Steben, and Wipfeld.

Pine-needle and Herb Baths may be made at home by using the extract of pine-needles prepared at the institutions or by Simon, of Berlin (about half a pound to a bath), or the extract of aromatic herbs, chamomile, gentian, calamus, mint, juniper, marjoram, etc. (one pound to a bath). The cheapest aromatic bath is that made from clover blossoms. As baths these probably have no specific action, but the volatile constituents perhaps penetrate the skin and enter the lungs. They are used as tonics.

Cold-water institutions, where pine-needle baths may be had, are at Alexanderbad, Cleve, Dietemühle, Elgersburg, Ilmenau, Johannisberg, Kreischa, Liebenstein, Nassau, Nerothal, Schweizermühle, Ruhla, and many other places. At Sharon Springs, N. Y., these baths have recently been given.

In Sand Baths the patient is covered wholly (except the head) or locally with sand at a temperature of 48° to 53° C. (118° to 127° F.), for an hour or so; after which he takes a warm water bath and is cooled off. The temperature of the patient rises rapidly, and he sweats profusely. Sand baths can be used hotter and longer than water or steam baths, on account of the slower conduction of heat and continued evaporation from the skin. It is desirable to measure the bodily temperature frequently during the bath. Sand baths are useful in the

same complaints as are benefited by warm and hot baths generally.

TAN, MUSTARD, MALT, AND BRAN BATHS act as warm baths with a cutaneous irritant added. A tan bath may have from four to six pounds of tan; a mustard bath from three to eight ounces of mustard.

ARTIFICIAL MINERAL WATERS are probably as efficacious as the natural ones, and from the greater proportion of carbonic acid which they contain are usually more agreeable; but the circumstances under which they are generally taken are not so favorable. Artificial mineral waters must be made from distilled or filtered water of known purity, not from the water of wells sunk in a city and acquiring filth by drainage. For the sake of cheapness, mixtures of salts may be dissolved in water. In the place of Ems water two parts of bicarbonate of soda and one of chlorate of soda may be used, a heaping teaspoonful of the mixture being dissolved in a quart of hot water. Carlsbad salt, as supplied from the spring, is chiefly sulphate of soda, because in the evaporation carbonate and chlorate of soda have been thrown away. An artificial Carlsbad salt may be made from sulphate of soda, cryst., 50; bicarb. soda, 20; chlorate of soda, 10 parts.

Bitter water may be made from sulphate of magnesia and sulphate of soda, 50 Gm. of each to a quart of water.

Hunyadi Janos may be substituted by 30 Gm. magnes. sulph., 35 Gm. sodæ sulph., and 1 Gm. sod. chl. to one quart of water.

Friedrichshall water is about 14 Gm. sodæ sulph., 10 Gm. magnesiæ sulph., 8 Gm. sod. chl., and 4 Gm. magnes. chl.

The composition of various mineral waters in America and Europe is given in the U. S. Dispensatory for 1883.

In ordering baths we must remember the amount of water and the proportion of salts. A full bath for a child may contain ten or twelve gallons; for an adult, from sixty to eighty gallons. So a one per cent. solution would require, approximately, nearly one pound of the salt for a child's bath, and five or six pounds for an adult's. For salt baths, the so-called rock-salt is good and cheap.

Sulphur baths may be made by adding from 60 to 120 Gm. hyposulphite of soda to a bath, and, while the patient is in it, pour in from 30 to 60 Gm. of vinegar.

An iron bath may be prepared from sulphate of iron, 60 to 240 Gm., and, to produce the carbonic acid, 60 to 90 Gm. bicarb. sodæ and 10 to 15 Gm. tartaric acid, etc.

The conditions for which water treatment is chiefly recommended are as follows:

Diseases of the Respiratory Organs.—Chronic catarrhs are treated by drinking alkaline, salt, iron, or sulphur waters, according to the general condition of the patient and to the kind of climate to which he should go; by inhalation of atomized alkaline or salt waters; by baths. As elsewhere suggested, much of the benefit from the water treatment may be due to other things, hence this mode of cure employed at home is not so successful as at the springs.

Chronic pneumonia and consumption are treated at the same class of springs.

Diseases of the heart are rarely suited for treatment by mineral waters. Fatty deposits about the heart, with general obesity, may be benefited by proper treatment at Carlsbad and similar springs. Where there is congestion of the abdominal organs, bitter waters, etc., may be given. If there is nervous irritability of the heart, sea baths may be carefully tried.

Nervous Diseases.—Cases of general nervousness, hysteria, hypochondria, neuralgias, paralyses, not of recent origin, and chronic diseases of the spine and its membranes, are often much improved by a course of water treatment.

Diseases of the Digestive Organs.—In chronic gastric and intestinal catarrhs, in which there is abnormal acidity, with eructations, the alkaline waters are best; where there is excessive mucus, atony, and sluggish action of the stomach and bowels, the alkaline-muriatic and alkaline-saline waters are suitable. In dyspepsia with hypochondriasis, from overwork, sedentary life, etc., sea baths and other hydropathic procedures may do good. It is well to use these waters warm.

Affections of the bile-ducts and urinary passages are treated by alkaline, alkaline-muriatic, and saline waters; urinary calculi by alkaline and alkaline-saline waters; phosphate of lime by free use of carbonated water; oxalate of lime by alkaline carbonates and acid waters, together with warm baths.

In diseases of the *uterus and its adnexa* water-cures have been greatly resorted to, and undoubtedly are often of great benefit by their hot douches, baths, and drinking of mineral waters, and more especially by the improvement of the general health and change of mental condition.

In *anæmia* the iron springs, so often recommended, are perhaps not much more beneficial than others, but the air, milk diet, warm salt baths, and attention to the cause of the anæmia are useful. Where the anæmia is induced by chronic metritis or peritonitis, bog baths are indicated.

For *obesity* the alkaline-saline springs—the water to be used warm if the patient is feeble, or cold if he is plethoric, together with pedestrianism—are recommended.

In *scrofula*, warm or cold sea baths, brine baths at home, drinking chloride of sodium waters, baths in highly carbonated waters, bog or mud baths, are used.

In *chronic rheumatism and gout* warmth is the important thing; hence warm or hot baths should be taken—whether of water, steam, sand, or mud, local or total, will depend greatly on the special case. Drinking mineral waters may be for the purpose of promoting the sweating induced by the bath, or the more thoroughly to wash out the system (especially in gout); or perhaps exudations about the joints may be absorbed by the use of alkaline and allied waters. "Hardening" the body after this treatment, by cold baths, frictions, etc., is desirable.

In *diabetes* mineral waters probably act beneficially only by relieving some of the accompanying symptoms, constipation, intestinal catarrh, etc., and the baths are useful in eczema, furunculosis, etc.

In *syphilis* warm and hot baths may hasten the appearance of roseola, etc., and so induce earlier resort to specific treatment, and, combined with the latter, have a favorable effect on the skin symptoms. Water treatment is good in cases in which mercury and iodide of potash have been used improperly or too freely, or in which the patient is much debilitated. To the latter cases sea baths are often suited; the sulphur baths are especially popular in this disease.

Chronic metal poisoning is treated hydropathically for the purpose of eliminating the poison by the increased excretions which result from the use of baths and drinking-waters, and in such cases more depends on the amount of water drunk than on its constituents. The sulphur waters are the most popular, but the choice of the waters should depend on the general symptoms. Hot baths increase the breaking down of albumen, and may thus prove beneficial.

Of *skin diseases* only some are benefited by baths, such as psoriasis, prurigo, pityriasis versicolor, seborrhœa sicca, acne, etc., all with little secretion; but these call for no further consideration in this place, as they are treated of elsewhere.

Now let us speak of simple baths, when the effect depends on the temperature of the water and on the mode of administration.

It is claimed that the chief danger in many diseases is from the high bodily temperature, and it is asserted that if this rises above 42° C. (107.6° F.), life is in imminent danger, and can only be prolonged by the rapid reduction of the fever; in the same way a prolonged elevation of from 2° to 4° C. (3½° to 7° F.), results in consumption of the nitrogenous tissues and increased excretion of urea, and finally in death of the patient from failure of the heart or brain, from the parenchymatous degeneration.

The more we believe in the high temperature being the cause of death, the more active will be our efforts for its reduction. The most natural way to cool something

Balneotherapeutics.

which is hot is to dip it in cold water; but the human body has the faculty of regulating its temperature by regulating the loss of heat and the subsequent production. When the surrounding atmosphere is warm, blood flows to the surface, the perspiration is increased, and its evaporation cools the person; when it is cold the cutaneous vessels contract, and blood goes to the internal organs. This regulation of heat-production causes the difficulty in treating fevers, for when the temperature has been reduced it again rises. If the amount of heat abstracted be excessive, after a time the reproduction diminishes and the temperature falls permanently. After the efforts at lowering the temperature have been discontinued, this often continues to fall for some time. To be successful this treatment must be pursued energetically and repeatedly till the temperature remains low. At first it may be necessary to repeat the bath ten or twelve times in twenty-four hours. The effect of the means used will depend on many things,—on the size and the degree of fatness of the patient, as well as on the relation of the time of day to that at which there would be a natural fall of temperature, and also on the fact that when the temperature is falling the bath is more effective. If it is rising when the bath is given it is less effective; hence baths are said to cause most abstraction of heat when given in the evening, or especially after midnight. If we try the temperature of the water immediately before and after the bath and multiply the number of kilogrammes of water in the bath by the increased temperature, it gives the number of calorics removed from the body. (A caloric is the amount of heat required to raise one kilogramme of water 1° C.)

One of the most effective and common ways of abstracting heat is by the cold full bath; the effect of this is proportioned to the coldness of the water and duration of the bath. A bath of 20° C. (68° F.) has more than twice the effect of one at 28° C. (82° F.). Liebermeister thinks that for an adult the bath should be about 15° C. (59° F.), and, as the greatest amount of heat is given out at first, that the baths should be brief and frequent; he thinks the effect of tepid baths does not compare with that of cold baths, unless in the case of children, in whom the proportion of surface is so much greater as compared with the interior of the body.

Ziemssen, in some cases, recommends baths begun at 35° C. (95° F.), and cooled in ten or fifteen minutes to 20° C. (68° F.) ("graduated baths"); the patient may remain in the bath from twenty to thirty minutes, till he feels chilly or the teeth chatter, when he should be put in a warm bed. This is the only bath permissible in some cases in which the heart is feeble or the patient very sensitive. Some claim that baths are much more effective and give less shock than douches; but the latter may be tried for deficient respiration or comatose conditions. If the effect on the head is all that is desired, the body up to the neck may be immersed in a warm bath, while the head is douched; if the respiration is to be stimulated during the douche the chest may be lifted out of the water and afterward submerged again; the latter procedure may be useful in poisoning by carbonic oxide or opium.

According to Liebermeister, the most marked effect was produced by baths taken during the night; the reduction of the temperature was greater in typhoid fever than in pneumonia, and it was more marked in men than in women (possibly from the greater amount of subcutaneous fat in the latter).

In deciding when abstraction of heat may be resorted to, Leichtenstern claims, "A man can suffer no harm from cooling as long as his temperature does not go below the normal point;" thus one who has been heated by a Turkish or Russian bath can take a cold plunge and so cool off suddenly without injury. The bath being about the temperature of the room, the patient may be kept in it ten minutes; or if he gets chilly, only seven or five minutes. Then he should be put to bed (without drying) and covered with dry clothes.

Thin patients or young children should not take baths so cold or so long continued as those taken by adults and stout persons. When the temperature rises to 39° C. (102.2° F.) in the axilla, or 39.5° C. (103° F.) in the rectum, the bath should be repeated, every two hours if necessary.

Liebermeister considers abstraction of heat permissible and advisable in any acute febrile disease, when the temperature rises to a high degree. In chronic diseases with fever (as phthisis), it is also applicable.

Contra-indications are hæmorrhages; feeble heart due to the fever or pre-existing disease; long continued depression following the bath; menstruation, unless danger from the fever is imminent. The same authority states that, unless the fever is so high as to demand special treatment, he would not resort to baths in cases in which the cause of the fever can be removed, as is true of cases of abscess, of intermittent fever, of rheumatism, etc. When the temperature is above 39° C. (102.2° F.) for a length of time, we should not wait for dangerous symptoms to begin baths. We need not expect to arrest the fever entirely; it is sufficient to obtain decided remissions of some duration.

In giving baths to typhoid patients, it is advisable to have a bath-tub long enough for the patient to lie in it with the shoulders covered by water. The tub should be placed parallel and near to the bed, but separated from it by a screen; then it should be quietly filled, the screen removed, the patient lifted into the tub, and some cold water poured over his head. While in the bath the patient should be gently rubbed; then he should be removed, clothed, the feet wrapped in flannel and, if necessary, hot bottles put to them. If the water has not been fouled by the patient, it may be used over again.

The physiological effect of the bath varies with the duration and temperature: the latter may be from 6° to 12° C. (43° to 54° F.). The nervous excitement produced by the low temperature and the sudden impression of cold, is considerable, as is also the abstraction of heat; at the same time the subsequent reaction is more intense than is the case with any other form of bath; hence, the marked tissue-changes.

The *half-bath* is given at a temperature of 15° to 25° C. (59° to 77° F.) for five to fifteen minutes; while the patient is in the bath a cold compress is kept on his head; this causes less shock to the nervous system.

Foot-baths, in which the feet are covered with water, hot or cold, are used for various purposes. The hot foot-bath, rendered more active by the addition of mustard, is used in feverish complaints with headache. After the bath the patient is wrapped up warmly and a hot drink is given to him; after which he usually sweats profusely. Cold foot-baths are employed in congestive headaches; after the bath the feet are rubbed briskly.

Cold bathing in a wash-basin is the simplest form of applying hydrotherapeusis. By it the skin is cleansed, and it induces some nervous stimulation. Cold sponging is an easy way of cooling off a fever patient.

Cold frictions are made by applying a towel wet with cold water to the body, and rubbing briskly over it; over the abdomen the friction should be in a circle, and the stomach should not be pressed upon; then the moist cloth should be replaced by a dry one, and the rubbing repeated. This acts as a stimulant, the respiration becomes more powerful, the pulse slower. The enlarged blood-vessels on the surface cause reduction of blood-pressure; there is derivation of blood from the internal organs. It is in this way that beneficial effects are produced in emphysema and catarrh of the respiratory and intestinal organs.

Cold Wet Pack.—A blanket is laid on a bed, and a wet sheet is placed on it; on the middle of this the patient lies down on his back, the arms crossed, and the legs extended and close together; the sheet is next folded tight over the body, close up to the chin and between the legs, so as to touch all parts; then the blanket is to be placed tightly over the patient in the same way. A cold wet compress should be applied to the head. Besides this method of packing the entire body, individual parts may be treated in the same way.

The effect of the general pack is first to stimulate the peripheral nerves when the surroundings have been

brought to the temperature of the body, abstraction of heat ceases, the pulse and respiration become less frequent, the cutaneous vessels dilate, there is restfulness and inclination to sleep. If the escape of heat be impeded by the wraps for a length of time, the temperature will rise, perhaps, in ten minutes; if the object be to lower the bodily heat, as soon as the pulse begins to rise the pack must be renewed; with successive renewals the temperature rises more slowly (in fifteen to twenty minutes), till finally it is arrested at a satisfactory point. Liebermeister thinks that four packs have about as much effect as one cold full bath. But the patient must be watched to see that reaction takes place; it may be necessary to apply hot bottles, etc., to the feet. When the pack is over, the relaxed cutaneous vessels should be toned up by cool sponging and friction.

The pack may be used in high temperatures from idiopathic fevers, catarrhs, inflammations, rheumatism, gout, etc.; it is also beneficial in neuralgias, lumbago, etc., and to cause absorption of exudations.

In the *Medical Record*, 1877, is described G. W. Kibbe's cot, which is a common cot-bed covered with cotton netting; on this is placed a sheet upon which the patient lies; the sheet is folded over him and then wetted with cold water. Under the netting is a rubber sheet to catch the water and convey it into a bucket.

Cold douches and *plunge-baths* have a combined mechanical and thermic effect, which varies with the amount and temperature of the water and the height from which it is poured. The patient being in a tub, cold water may be poured on the head or body from a height, or it may be sprinkled over him; of course, the colder the water, the greater the height, and the larger and more continued the stream, the more decided will be the effect.

In a *sitz bath*, as the name implies, the patient sits in water, the body being covered with a blanket; cold water causes contraction of the abdominal vessels, hot water the opposite. Cold sitz baths, of 8° to 15° C. (46° to 59° F.), continued ten to thirty minutes, reduce the amount of blood in the abdominal organs, viz., the liver, spleen, etc., and are used in enlargement of these organs, and in diarrhœas. The opposite effect is induced by baths continued but a short time (five minutes); these are employed in sluggish circulation in the liver and spleen, and inactivity of the bladder or bowels.

The *moist compress*, of pieces of linen or muslin, of variable size or thickness, wrung out of cold water, is applied to different parts of the body; when applied around the body it is called Neptune's girdle, and is applied like a bandage, only the part which goes next the body being wet. The object of the cold compress is the reduction of the blood-supply, and the temperature. It may be left on the part, and be kept wet by dropping water on it by a siphon arrangement. Cold compresses are applied in the same way to the head, chest, calves of the leg, throat, etc.

Sometimes it is desired to get the cooling effect of cold water without the wetting; this may be accomplished by passing water, siphon fashion, through rubber or metal tubes; one end of the tube being fastened in a bucket of water, the other end being arranged so that water flowing through it may pass into some receptacle, while the intermediate part may be disposed in such a manner as to fit any portion of the body, by being coiled on itself and fastened to a piece of muslin to keep it in shape. A similar arrangement may be used for the rectum or vagina.

Chapman's ice-bags would come under the same heading. These are made for the purpose of applying ice along the spine, with the idea of alternating this application with that of heat over that part of the spine in which lies the central organ of the part we desire to affect.

Ice-bags applied over the heart reduce the frequency of its pulsations; applied to the head, they often beneficially affect the brain. Drinking cold water, eating ice, etc., lower the temperature by so much as is required to heat them to 100° F.

Cold enemata, for the purpose of reducing bodily temperature, may be given by means of a rubber tube several feet long, with a nozzle to insert in the rectum at one end, and at the other end a tin receptacle for holding the cold water. When we wish to inject the water, the receptacle must be elevated; when the patient feels that enough has entered the bowel, the vessel should be lowered and the water will flow back into it; fresh water may be used, and the operation repeated, without removing the nozzle, till the temperature in the axilla has been reduced some degrees. Where this procedure answers the purpose, it is more easily carried out than bathing.

The above represents fairly the present status of Balneology in Germany, where it has of late been most accurately and extensively studied.

Balneotherapeutics may trace its origin far back, baths having been employed therapeutically by Hippocrates and other ancient authorities. Like many other modes of treatment, it has gained and lost in popularity. For a complete history of balneotherapeutics, see Liebermeister's article in Ziemssen's "Allgemeine Therapie," vol. i

Let us now look at some English and American views.

At the end of the last century, James Currie, M.D., of Liverpool, published his "Medical Reports," in which he gives the results of very careful observations on the effects of cold affusions in various diseases. He preferred salt-water in the proportion of one part of salt to about twenty-four of water, and, in sthenic patients, of a temperature of 40° to 50° F. in the early stage of disease.

Later he gives some account of an epidemic of typhus which occurred among French prisoners at Stapleton, in 1805, and here douches were used according to his plan in 815 cases; over 300 cases were cut short; of the remainder, 41 died—that is, about five per cent. of the entire number, which is as successful as the results of more recent observers.

Currie used the thermometer (he even had a self-registering thermometer) in his cases, and, in typhus cases especially, he began his affusions when he found the temperature above normal and the patient not feeling chilly, particularly if there was any delirium. When the cases were properly selected, he claims that there was almost universally a clearing of the intellect, refreshing sleep, and general improvement; if the fever recurred, the douche was repeated. The patient was stripped, and cold salt-water poured over the head and body. In some cases this was repeated ten or twelve times the first day; subsequently, perhaps once daily.

Currie claims that there is no absorption through healthy skin, basing his conclusion on his own observations and those of M. Seguin.

He says that cold affusion is best used in continued fever, when the temperature has begun to decline, usually about 6 to 9 P.M., "When there is no sense of chilliness present, when the heat of the surface is steadily above what is natural, and when there is no general or profuse perspiration."

If the perspiration has just begun, there is little risk; but if it has continued for some time, the cold douche is dangerous. When it is used in advanced stages of the disease, some form of stimulus may be given at the same time. In the early stages (first three to five days) Currie employed water having a temperature of 40° to 50° F., saturated with sea salt, or, in feeble cases, water only 15° to 20° below the normal body-heat. At the same time he gave an opium draught at bedtime, and attached importance to having the bowels evacuated daily (in typhus).

The coincident exhibition of calomel, or even the presence of salivation, was not considered by him to be an adequate contraindication.

Currie used the douche also in variola, scarlatina, and intermittents.

He says that during the cold stage the drinking of cold water should be avoided, but during the hot stage it may be drank freely, the more so the higher the fever; but it should be forbidden when sweating is free.

Plunging the patient into cold salt-water is highly rec

ommended in tetanus and other convulsive disorders, especially during the convulsion, which is shortened or arrested, and its return is retarded or prevented.

The *London Med. Times and Gazette*, March 1, 1884, contains a report of a paper by Dr. Sidney Coupland, favoring the use of cold baths in typhoid fever, with a report of the discussion which took place on it before the London Medical Society. The opposition was led by Dr. Bristowe. Dr. Coupland claimed "that the cold bath treatment, *when commenced early and carried out systematically*, tended to abort the disease, to minimize the sequelæ, to hasten recovery, and to lower the mortality of typhoid fever." The editor says, "We must frankly admit that we were not quite prepared for such an almost complete agreement in professional feeling on this subject. The cold bath treatment of fever seems, at first sight, somewhat unnatural; it runs counter to some of our most cherished notions; it goes contrary to popular traditions and popular prejudices. . . . One remarkable outcome, and its correctness was amply corroborated by other speakers, was to show that pulmonary troubles are considerably lessened by this plan of treatment, these popular traditions notwithstanding. Another outcome was to show that the characteristic—the intestinal—lesions are the most serious, the most to be dreaded, and the least amenable to any form of treatment. Death, however, not infrequently occurs in consequence of these causes, and all the evidence went to show that these accidental consequences are largely and favorably influenced by the cold bath treatment, while deaths from purely hyper-pyrexial causes are almost abolished."

Dr. George L. Peabody (*New York Medical News*, 1884) gives some tables showing the mortality of typhoid fever under expectant treatment, in the armies of Germany and the United States, and compares this with cases treated by cold water, showing a difference of over fifty per cent. in the death-rates; under the former, from eighteen to forty-nine per cent. being lost; while, under the latter, about ten per cent. or less died. While urging the use of cold baths, especially early in the disease, he says, "It is not claimed that all cases can be safely or properly subjected to prolonged cold bathing. As contra-indications may be mentioned intestinal hæmorrhage or perforation, or peritonitis; aphonia from ulceration of the larynx, which may threaten œdema of the glottis; marked degrees of heart weakness, in which the internal temperature is high, with cool extremities, pulse and heart impulse being very weak; also venous congestion from chronic bronchitis, emphysema, and heart disease."

While having faith in the efficacy of cold water in cases of typhoid fever, when early applied, the writer feels less obliged to resort to it since he has seen the effects of antipyrine. When this remedy is given to a patient with a temperature of 104° F. or more, in the dose of ʒ ss. repeated after one hour in the same dose, and in another hour in a dose of gr. xv., it will usually lower the temperature three or four degrees, leaving the intellect clear and tongue clean. This may be repeated when the temperature rises, just as is advised in case of the bath.

Dr. W. M. Ord reports two cases of *acute rheumatism*, in which the bath was employed; in one the temperature was 106°, and during the bath it fell to 96.5°; in the second it was 106.4°, and fell to 96.6°. The effect in both cases was lasting; in both salicylate of soda had previously been tried ineffectually.

In *Insolation*, treatment by baths is most successful. The writer of this has seen several cases, in which the temperature rose to 109° and 110°, recover promptly under baths and the internal use of water.

So far as the writer has been able to discover, the bath treatment of typhoid fever in hospitals in America has not been so successful as in Germany. Possibly a reason for this may be found in the fact that our patients may come under treatment later in the disease, having better means for being treated at home, till it is found that they are really going to be ill for a length of time.

In "water cures," among the most frequent ailments treated are indigestion, abdominal plethora, inducing habitual constipation and engorgement of the ovaries and uterus, with the endless series of indefinite so-called "womb troubles." In such affections compresses moistened with ordinary or saline waters, and called "hydrotherapeutic belts," applied over the abdomen for an hour or so at a time, combined with drinking freely of water, early hours for retiring and for rising, with simple diet, sometimes work wonders.

A tendency to "catch cold" from fatal facility to perspire may be combated by baths. In such cases it is often desirable not to employ too much *water*, but to expose the body freely, giving an air bath.

Chas. E. Hackley.

BALSAM OF PERU (*Balsamum Peruvianum*, U. S. Ph., Br. Ph., Ph. G.; *Baume de Pérou noir*, *Baume San Salvador*, *Baume de Sansonate*, Codex Med.). A partly empyreumatic, liquid, resinous product, obtained from *Toluifera Pereiræ* Baillon; *Myroxylon Pereiræ* Klotsch. Order, *Leguminosæ Papilionaceæ*. This is a good sized tree, with a dark, smooth trunk, branching near the ground. It attains often a height of sixteen or eighteen metres (fifty feet), and resembles, in its botanical characters, *T. Balsamum*, described in the succeeding article.* The tree is a native of Central America, and protected, but not really cultivated, as a source of the balsam, in the Indian reservation lands of San Salvador, along the Balsam Coast. It has been introduced into Ceylon, where it flourishes vigorously.

FIG. 377.—The plant yielding Balsam of Peru, *Toluifera Balsamum*, Miller. (Reduced.) (Baillon.)

Balsam of Peru was one of the earliest products carried to the Old World from Central America, and was at first extravagantly prized for its medicinal properties, as well as for its use as incense in the Catholic churches. It was at first exported indirectly, by way of more southern South American ports, and by this means it received its misleading name of Balsam of *Peru*. None is now, or ever has been, *produced* in the state of Peru.

The collection is made in November or December, at the end of the rainy season, when the bark is full of resin. The Indians, to whom the trees belong, then beat the trunks on four sides with the heads of their axes, or with hammers, so as to bruise four strips of bark, and leave as many similar ones untouched. After a few days, they scorch or ignite the contused surfaces with torches, which serves to increase the flow of resin, and then, waiting another week, tear off the loosened strips of bruised bark and swathe the stems in rags, to absorb it. When the cloths are saturated, they are boiled in a vessel of water, and the balsam melted out of them collects in the bottom, and is easily separated. The trees are not killed by the process; the following year the remaining portions are

* Indeed, so close is this resemblance, that M. Baillon does not believe their difference is sufficient to make a distinct species of the present tree. Hanbury, in the *Pharmacographia*, gives the following tabular view of their difference: "*M. Toluifera:* trunk tall and bare, branching at forty to sixty feet from the ground, and forming a roundish crown of foliage. Calyx rather tubular. Racemes dense, three to four and a half inches long. Legumes scarcely narrowed toward the stalk-end. *M. Pereira:* Trunk throwing off ascending branches, at six to ten feet from the ground. Calyx widely cup-shaped, shallow. Racemes loose, six to seven inches long. Legumes much narrowed toward the stalk-end.

submitted to the same, and in the second year those operated upon first; so, by judicious treatment, a continuous annual yield is obtained.

DESCRIPTION.—Balsam of Peru is a dark, thickish liquid, looking, at a little distance, like dark molasses; when shaken up upon the sides of a containing glass, the thin layer so obtained is yellowish, or reddish-brown, and transparent. It has a rather smoky, but not unpleasant balsamic odor, and a taste, which, at first mild, becomes later, in the fauces, warm and acrid. It is heavier than, and insoluble in, water; yielding to it only a little free cinnamic acid, but mixes freely with chloroform and absolute alcohol. It does not dry, or undergo much change, upon exposure to the atmosphere, and should contain neither essential oil nor fats.

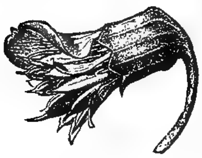


FIG. 378.—Flower of Toluifera Balsamus. (Enlarged.)

The composition of the balsam is not very simple, but the principal constituents are: 1. A *resin*, insoluble in carbon bisulphide, which may be separated by means of that agent. It is hard, brittle, inodorous; constitutes from thirty-eight to forty per cent. of the whole, and yields benzoic acid, etc., by distillation. 2. Nearly sixty per cent. of *cinnamein*, a brownish, aromatic liquid (benzylic cinnamate, which this is supposed essentially to be when pure, is a crystalline solid). 3. Traces of *cinnamic* and *benzoic acids*.

ACTION AND USES.—It is generally classed with stimulating expectorants, to which position it has very little claim, as, in ordinary doses, its action upon the air-passages other than the pharynx, which it comes in contact with, must be exceedingly small. There is more reason for expecting some effect from it upon the urinary mucous membranes, but here it is said to be far inferior to copaiba, and similar substances employed for catarrhs of this tract. Its employment in amenorrhœa, chronic rheumatism, etc., has been purely empirical, and probably useless. Locally it is a mild stimulant, and may be useful as an application to slow granulating surfaces. Its non-drying qualities would, in certain cases, give it a mechanical advantage over other resins. It is, however, very little used in medicine. *Dose*, one or two grammes (gr. xv. ad gr. xxx.), in capsules, on sugar, or in a syrup or mucilaginous emulsion.

FIG. 379.—Fruit of the Above. (Enlarged.)

ALLIED PLANTS.—BALSAM OF TOLU. For the order *Leguminosæ*, see SENNA.

ALLIED DRUGS.—A gum resin exudes, naturally, from the trunk, and an essential oil may be distilled from the leaves of the same tree, but neither is used. Peru balsam holds an intermediate place, in its action, between the other balsams and mild resins, such as benzoin, balsam of Tolu, styrax, as well as ammoniac, galbanum, myrrh, etc., on the one hand, and the tarry substances, oil of cade, tar, etc., on the other. On account of its expensiveness it is frequently adulterated. *W. P. Bolles.*

BALSAM OF TOLU. (*Balsamum Tolutanum*, U. S. Ph., Br. Ph.; *Baume de Tolu*, Codex Med.) A resinous product from *Toluifera Balsamum* Miller; Order, *Leguminosæ, Papilionaceæ*. The tree producing this balsam has suffered several vicissitudes in the matter of nomenclature: first called in 1623, by Bauhin, by the same name as that used now for its product (*Balsamum tolutanum*), it was, a hundred years later, named *Toluifera Balsamum* by Miller, which name was accepted by Linnæus. Then the plant was, for a time, placed in the genus *Myrospermum*, as *M. tolutiferum*, A. Rich, and finally assigned to a new place and called *Myroxylon Toluifera*, by Kunth, a name now in general use. The French botanist Baillon, however, and the authors of "Medicinal Plants," have returned to the older one given by Miller, *Toluifera Balsamum*, as most in accordance with their sense of botanical traditions and justice.* The plant itself, which was long only imperfectly known, was made familiar a few years ago through the joint efforts of Mr. Hanbury and a naturalist named Goering, who was, at the time, travelling in South America. He, at the request of the former obtained the first complete botanical specimens, as well as some seeds, from which plants have since been grown.

It is a fine, large evergreen tree, with a tall, straight stem, often rising from thirteen to nineteen metres (40 to 60 feet) without a branch, then bearing a fine round crown. It has alternate glandular, odd-pinnate leaves, of from seven to eleven divisions. The flowers are small, in axillary racemes, not very irregular; the calyx is monosepalous and tubular. The petals distinct, the upper ("standard") large and broad, the others small and narrow; stamens ten, nearly or quite distinct; ovary stalked, long, one- or two-seeded at the apex. Fruit winged below. The leaves contain abundance of fragrant oil, the branches and stem are filled with oil and resin. It is a native of Venezuela and New Granada. The balsam has been exported from the latter state since the middle of the sixteenth century. It is collected by the Indians, and was already an object of value among them when the country was discovered.

COLLECTION.—Deep **V**-shaped incisions are made in the trunk, and at or below the point where they meet, a vessel is fastened to receive the exudation. These receptacles are usually calabashes or gourds, and many such may be arranged, at the same time, around the stem of a large tree. As they become filled they are emptied into leather bags, in which they are carried to the market or town, and there again, they are at present usually emptied into tin cans for exportation.

It is a soft, brown, resinous substance, when fresh sometimes thin enough to pour; usually soft enough to be dipped out with a spoon or spatula, but upon exposure becomes harder and finally brittle, although easily softened by warmth. It has a brown color, but in thin layers is yellowish, and either transparent or cloudy, by the deposition of crystals of cinnamic acid. The odor is delicate and very pleasant, recalling that of Siam benzoin, and improves by age. The balsam is almost insoluble in water, but freely soluble in alcohol and chloroform. Its principal constituents are *essential oil* in small but varying quantity: *resin*, from eighty to ninety per cent.; cinnamic and *benzoic acids*, together about twelve per cent., and traces of other related compounds. The resin can be separated into two resins by treatment with alcohol; by destructive distillation it affords benzoic acid and other products. (It is probably the same as the resin of balsam of Peru.)

The medicinal qualities of Tolu are even less marked than those of Peru balsam, as the acrid quality of the latter is almost wanting in the former; still it is very much the more in use, on account of its pleasant odor and taste. It is usually called expectorant, etc., and is a common ingredient in cough and similar mixtures, but in a form which is medically wholly inert, further than for a passing local effect upon the fauces. If given with any expectation of modifying the bronchial surfaces, it must be in doses of not less than one or two grammes (1 to 2 Gm. = gr. xv. ad xxx.) or, probably, better by vapor. Of the preparations, the syrup (*Syrupus Tolutanus*, U. S. Ph.), although nominally made with four per cent. of the balsam, in reality contains less than one per cent., and that of the oil and crystallizable acids only, not of the resin. It is simply a vehicle. The tincture, *Tinctura Tolutanum*, U. S. Ph., strength one-tenth, represents the entire balsam, but contains a large dose of alcohol in addition to the medicine in question. In the compound tincture of benzoin (*Tinctura Benzoini Composita*, U. S. Ph.) it is a subordinate adjunct. So the best ways to give the balsam internally and alone are by pill or an emulsion extemporaneously made. Both this and the preceding balsam are used in toilet soaps and for similar purposes, as perfumes, etc.

* For further information on this subject see Baillon: Histoire des Plantes, and Botanique Médicale; Bentley and Trimmen: Medical Plants, etc.; Hanbury: Science Papers, etc.

ALLIED PLANTS.—See the preceding article. For a notice of the order, see SENNA.

ALLIED DRUGS.—See the preceding article, also BENZOIN.

W. P. Bolles.

BALTIMORE. The accompanying chart, representing the climate of the city of Baltimore, Md., and obtained from the Chief Signal Office in Washington, is here inserted for convenience of reference. A detailed explanation of this and other similar charts will be found under the heading CLIMATE; where also the reader may find suggestions as to the best method of using these charts.

H. R.

Climate of Baltimore, Md.—Latitude 39° 18′, *Longitude* 76° 37′.—*Period of Observations, January* 1, 1871, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level,* 14 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	31.5	38.2	34.2	34.6	42.9	29.8	40.5	27.0	71.0	45.0	17.0	−6.0	21	30
February...	33.2	41.8	36.5	37.1	41.3	28.9	45.7	31.1	78.0	58.0	23.0	2.0	25	18
March......	38.2	46.9	41.4	42.1	49.1	36.9	51.0	36.1	76.0	59.0	27.0	5.0	26	26
April.......	48.7	58.8	51.3	52.9	58.8	46.9	61.4	45.1	84.0	68.0	42.0	23.5	19	21
May........	60.4	71.3	62.1	64.6	70.6	59.4	73.5	56.3	95.0	83.0	46.0	34.0	23	26
June.......	70.7	80.4	71.0	74.0	76.1	70.2	81.7	64.5	97.5	90.0	55.0	49.0	23	21
July........	75.3	84.9	75.5	78.5	81.5	75.8	86.8	70.0	99.0	93.0	65.0	59.0	20	20
August.....	71.4	81.4	73.1	75.3	79.5	72.6	83.1	67.4	98.0	88.0	63.0	52.0	23	23
September..	63.7	73.9	65.8	67.8	76.9	63.4	76.4	61.6	101.0	81.0	59.0	40.0	29	16
October....	53.4	63.8	56.0	57.7	63.1	51.8	67.7	52.3	89.0	73.0	44.0	30.0	23	20
November..	42.3	49.4	44.1	45.2	49.1	40.6	53.1	39.5	78.0	61.0	33.0	15.0	20	22
December..	33.9	40.6	36.5	37.0	43.8	28.4	42.7	29.2	71.0	51.0	24.0	−3.0	17	27
Spring......	......	......	......	53.2	57.3	50.9	......	......	......	......	......	......	......	......
Summer....	......	......	......	75.9	78.8	74.8	......	......	......	......	......	......	......	......
Autumn....	......	......	......	56.9	63.0	54.3	......	......	......	......	......	......	......	......
Winter.....	......	......	......	36.2	41.9	32.1	......	......	......	......	......	......	......	......
Year........	......	......	......	55.5	57.1	53.1	......	......	......	......	......	......	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind.*
						Inches.	From	Miles.
January...	77.0	70.8	13.2	7.0	20.2	3.05	N.W.	5.5
February..	76.0	66.8	12.5	7.9	20.4	3.08	N.W.	6.1
March.....	71.0	65.0	11.5	8.9	20.4	3.93	N.W.	7.1
April......	60.5	60.6	12.6	7.5	20.1	3.23	N.W.	6.8
May.......	61.0	60.9	11.9	10.8	22.7	2.82	S.E.	6.0
June......	48.5	64.5	15.6	7.2	22.8	3.94	S.	6.0
July.......	40.0	64.3	14.5	9.2	23.7	4.06	S.W.	5.6
August....	46.0	69.3	11.9	10.1	22.0	4.46	S.	4.9
September.	61.0	70.9	11.2	10.5	21.7	4.34	N.	5.2
October...	59.0	68.7	12.2	11.1	23.3	2.97	N.W.	5.3
November.	63.0	66.5	11.1	9.8	20.9	3.04	N.W.	5.5
December.	74.0	68.2	13.5	8.0	21.5	3.11	N.W.	5.7
Spring....	90.0	62.2	36.0	27.2	63.2	9.98	N.W.	6.6
Summer..	50.0	66.0	42.0	26.5	68.5	12.46	S.	5.5
Autumn...	86.0	68.7	34.5	31.4	65.9	10.35	N.W.	5.3
Winter....	84.0	68.6	39.2	22.9	62.1	9.19	N.W.	5.8
Year......	107.0	66.4	151.7	108.0	259.7	41.98	N.W.	5.8

* Miles per hour.

BALLSTON SPA. *Location and Post-office,* Ballstôn, Saratoga County, New York.

ACCESS.—Ballston is on the Saratoga & Champlain Division of the Delaware & Hudson Canal Co.'s Railroad, twenty-five miles north of Albany.

THERAPEUTIC PROPERTIES.—These waters are similar in their composition to those of Saratoga, but are richer in mineral constituents, especially the Ballston and Franklin Artesian Wells. For those desiring to use the water medicinally, and to avoid the gaiety and excitement of Saratoga, Ballston Spa offers every inducement. The waters are characterized by a large proportion of sodium chloride and carbonic acid gas; there are also traces of lithia, iodine, and iron. They are classed, generally, as carbonated saline waters, tonic, alterative, and cathartic.

ANALYSIS.

One pint contains:	United States, 50° F. Geology, N. Y.	Ballston Artesian Lithian Well. 52° F. C.F.Chandler.	Franklin Artesian Well. 52° F. C. F. Chandler.	Conde Denton-ean Well. 49° F. C. F. Chandler.
Solids.	Grains.	Grains.	Grains.	Grains.
Carbonate of soda..........	2.11	1.034	8.200	2.982
Carbonate of magnesia.....	0.72	13.378	13.175	11.729
Carbonate of iron..........	trace.	0.143	0.146	0.208
Carbonate of lime..........	3.65	20.675	17.565	15.494
Carbonate of lithia........	......	0.701	0.613	0.950
Carbonate of strontia......	......	0.083	trace.	0.018
Carbonate of baryta........	......	0.397	0.125	0.484
Chloride of potassium......	......	4.159	4.241	1.154
Chloride of sodium.........	53.12	93.753	82.418	80.685
Sulphate of potassa.........	......	0.065	0.095	trace.
Sulphate of soda............	0.22	......	......	......
Phosphate of soda..........	......	0.006	0.001	trace.
Iodide of sodium............	......	0.015	0.029	0.028
Bromide of sodium..........	......	0.455	0.583	0.296
Fluoride of calcium........	......	trace.	trace.	trace.
Biborate of soda............	......	trace.	trace.	trace.
Alumina.....................	......	0.009	0.032	0.049
Silica........................	1.00	0.095	0.092	0.128
Organic matter..............	......	trace.	trace.	trace.
	60.82	134.968	127.315	114.205
Carbonic acid gas, cub. in..	30.50	53.26	57.51	44.79

George B. Fowler.

BANDAGING. Bandages are made of linen or cotton cloth, flannel or caoutchouc. Flannel is used when moderate and firm pressure is desired, and caoutchouc when more forcible constriction is sought for; but for ordinary purposes the best material to employ is unbleached muslin of not too coarse texture. The usual form of ban-

dage is what is known as a "roller-bandage," and it is to this that the following remarks apply, unless otherwise stated. From six to eight yards is the most convenient length, for if longer than that the bandage makes a bulky roll, which is awkward to handle. The width may vary from one to three inches, according to the size of the parts to which the bandage is to be applied; for ordinary purposes, as for the arm or leg, two inches is a suitable width. The strips are to be torn, and not cut, and the selvage should always be rejected, as, by reason of its inelasticity, it interferes with the proper adjustment of the bandage, and may also cause constriction and excoriation of the skin. For convenience of application the bandage is wound tightly around itself in the form of a cylinder, called a roll. This is accomplished in the following manner: The end of the bandage being laid smoothly on the thigh in the direction of its long axis, it is rolled over itself into a little cylinder by a sliding motion of the hand on the thigh. When this cylinder is of sufficient thickness, about half an inch in diameter, it is grasped between the thumb and fore-finger of the right hand, and the un-rolled portion is made to pass between the extended thumb and forefinger of the left hand. Then the right hand, holding the cylinder at its poles, is supinated, drawing in this way the slack of the bandage on to the roll. When this movement has gone as far as possible, the roll is steadied between the thumb and middle-finger of the left hand, while the right hand is pronated so as to grasp again the poles of the cylinder in the original position (see Fig. 380). These movements are repeated until the whole bandage is rolled, the tightness of the roll depending upon the degree of friction to which the slack is subjected as it passes between the thumb and index-finger of the left hand. The pressure needed to keep the bandage tight is very tiresome to the thumb, and it is therefore a good plan to practise rolling with either hand, so that the bandage may be changed from one to the other. When many bandages are to be rolled, it is better to employ a machine. Fig. 381 represents a very convenient machine for this purpose, but any one of ordinary ingenuity can construct a perfectly serviceable roller out of a cigar-box and a piece of bent wire. After a bandage has been tightly rolled on a machine of this sort, it is sometimes difficult to slide it off of the wire axis; but this may be readily accomplished if the bandage be tightly grasped in the hand while a half-turn in the reverse direction is made with the crank.

FIG. 380.—Method of Rolling a Bandage.

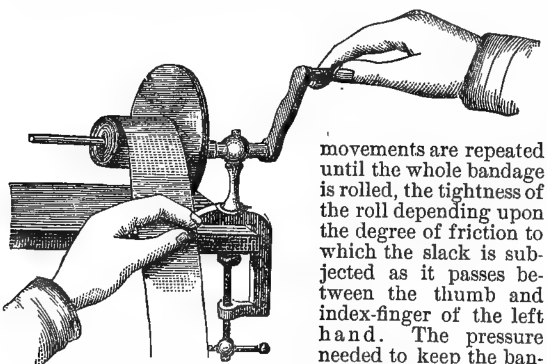


FIG. 381.—Von Bruns's Bandage-Rolling Machine.

In former times, when bandaging was much more of an art than it is now, and when the ability to apply a bandage neatly and according to rule was regarded as one of the essential requirements of a good surgeon, each form of application had its special name. Many of these terms are now obsolete, but as they are met with in the older works, and occasionally even in those of more modern date, especially in foreign books, a short list of those more commonly used may be appropriately given in this place: Ascia, fascia spiralis, or dolabra currens, a spiral bandage applied without reverses, each turn of which overlaps the preceding for about a third of its width; dolabra repens, the same as the preceding, in which, however, the spirals are formed more obliquely, and do not overlap each other, but are separated by a greater or less interval (see Fig. 382); figure of 8, a bandage passing from one part of a limb to another, and returning in such a way as to resemble this figure; stapes, a figure of 8 encircling the ankle and instep; spica, a figure of 8 embracing the trunk and the adjacent portion of a limb; testudo, a figure of 8 about an articulation, the turns crossing on the flexor surface and the spirals overlapping, so as to cover in the extensor surface of the joint; testudo inversa is one in which the spirals overlap one another from without inward, the last turn of the bandage passing horizontally over the centre of the joint (Fig. 383); testudo reversa is one in which the first turn is made over the joint, and the spirals diverge above and below; capistrum, or capelina, a bandage covering the cranium; mitra Hippocratis, a capeline made with a double-headed roller, or bandage rolled up from each end (see Fig. 391); bandage of Galen, or bandage of the poor, a six-tailed bandage used to cover the head (Fig. 384); fascia nodosa, Packer's knot, or knotted bandage, a bandage formerly used to make compression over the temporal artery (see Fig. 392); T-bandage, a bandage formed of two pieces united in the shape of a letter T; bandage of Scultetus, a bandage formed of a number of separate strips so arranged as to overlap one another when applied (Fig. 395); funda maxillæ, a four-tailed bandage, used as a sling for the chin (Fig. 396); reverse, a half-turn employed to change the direction of a bandage.

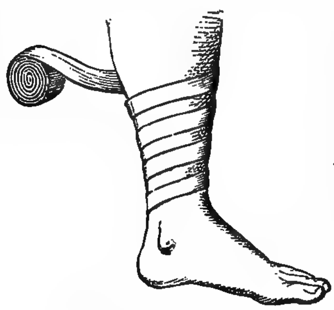


FIG. 382.—Dolabra Repens.

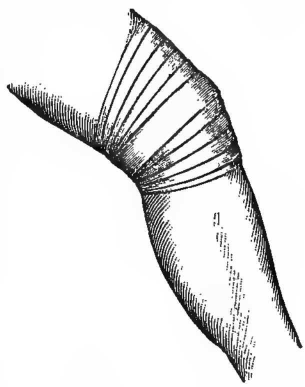


FIG. 383.—Testudo Inversa.

If a bandage is to be employed with the object of making pressure on any portion of a limb, it should start from the extremity of the member, the fingers or the toes, and extend uninterruptedly up to the point at which pressure is to be exerted, being applied snugly, though without constriction, to the lower portion of the limb in order to avoid the production of œdema. When, however, the object of a bandage is

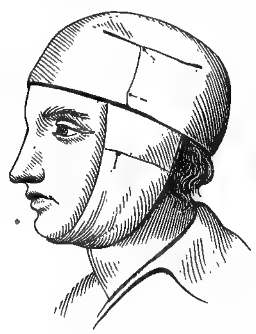


FIG. 384.—Bandage of Galen.

simply to retain dressings, as, for example, the plaster strips used in making traction on a member, it may be begun at any part of the limb, since in this case it is not to be applied so tightly as to cause constriction of the tissues. But, as the first few turns are usually the tightest, it is well, as a matter of precaution, to slit them up for about an inch with the scissors, after the bandage is applied.

We will consider first the application of the ordinary roller bandage to the different regions of the body, and will then describe briefly the other forms of bandage most commonly employed.

It is better, for the sake of neatness and uniformity, to make the turns of a roller pass from the inner to the outer side of a limb, and the student should therefore practise applying a bandage with either hand, and when standing in any position with relation to the limb to be covered.

The Lower Extremity.—A bandage from two to three inches in width, according to the size of the limb, is required. Two or three smooth turns being taken around the ankle, the roll is carried down at once to the toes across the dorsum of the foot. A couple of plain turns are now made in an upward direction, each turn overlapping the preceding for about one-third or one-half of its width, and then a few more are made with reverses over the back of the foot. The heel is now reached, and according as it is desired to cover it with the bandage or to leave it exposed, different procedures are necessary. When it is to be left uncovered, as soon as the dorsum of the foot is covered, the roll is carried up to the ankle and several figure-of-eight turns are made around the posterior surface of the ankle and the sole of the foot, overlapping across the head of the astragalus; this is called the stapes. If the heel is to be covered it is necessary to resort to the testudo. A turn of the bandage is taken directly over the centre of the heel and is succeeded by other turns above and below alternately, each one overlapping the preceding by one-half or two-thirds of its width. When the heel is entirely covered, the edges of the testudo are caught and held by a few stapes turns, and then the leg bandage begins. Some two or three ascending turns are made until the swell of the calf begins, when it is necessary to employ reverses. If these are not made the bandage will run up the limb in an open spiral (dolabra repens), and wide intervals will be left uncovered. A reverse is made by arresting the bandage as it runs obliquely across the front of the limb, holding it there with the thumb of the disengaged hand, and then folding it upon itself in a half-turn so as to alter its course and cause it to descend upon the opposite side of the limb (see Fig. 389). When the roll reaches the back of the leg it is transferred to the other hand, and then, but not till then, is drawn tight. A reverse cannot be made properly except with a slack bandage.

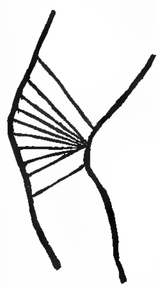


Fig. 385.—Testudo Reversa of the Knee.

The knee is to be covered in by several figure-of-8 turns overlapping each other toward the centre, until finally a single straight turn closes the remaining interval over the patella. This is the testudo inversa (Fig. 383), and is applicable to the knee in any position, whether of flexion or extension. When, however, the knee is flexed, and, indeed, in any case, the writer prefers the testudo reversa as being neater in appearance and more easy of application. It is made by commencing with a straight turn over the patella, and thence diverging in a gradually widening figure-of-8, as represented in outline in Fig. 385. It has the further advantage that, when the testudo is completed, the roller is on the thigh in position to continue its upward progress. The thigh is easily covered by simple reverses.

The spica bandage is a figure-of-8 enveloping a joint, the succeeding turns of which do not exactly coincide, but overlap each other in such a way as to produce a fancied resemblance to an ear (*spica*) of barley. According as the turns overlap each other from below upward, or from above downward, we have an ascending or descending spica; and according as they cross one another in front, behind, or at the side of the joint, the bandage is called an anterior, posterior, or lateral spica. There are several kinds of spica, as of the hip, shoulder, thumb, etc.; and it is called single or double, according as one or both hips or shoulders are covered simultaneously. It is a good practice always, before applying this variety of bandage, to put a layer of cotton in the axilla or groin to avoid irritation from the folds of the cloth. After making a couple of turns around the body in a direction away from the hip that is to be covered, the roller is carried down around the thigh, encircling it from without inward anteriorly, keeping well up in the groin, is then carried in an oblique upward line across the anterior surface, making the cross turn of the figure-of-8 over the lateral aspect of the hip, then across the abdomen, over the back, and down again to the thigh. The turn around the thigh is made as before, being carried a little lower so as to cover about one-half of the preceding turn. This is a lateral descending spica (see Fig. 386). The double spica is applied in a similar manner, except that the bandage is arrested as it is passing the second time across the abdomen to the hip, and is deflected around the opposite joint. It is then carried once more around the body before passing to the first hip, and so on. See Fig. 387, representing a double anterior descending spica of the hip, or double spica of the groin. A spica of the shoulder is usually made by beginning with two or three turns around the arm from within outward, then bringing the roller across the back, under the opposite axilla, over the chest, and around the

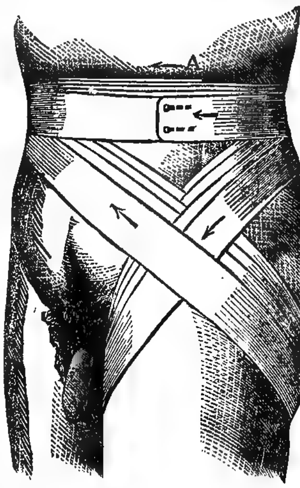


Fig. 386.—Single Lateral Spica of the Hip. (After Jaccoud.)

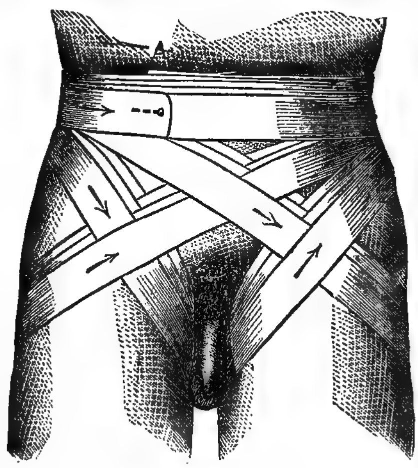


Fig. 387.—Double Anterior Spica of the Hip. (After Jaccoud.)

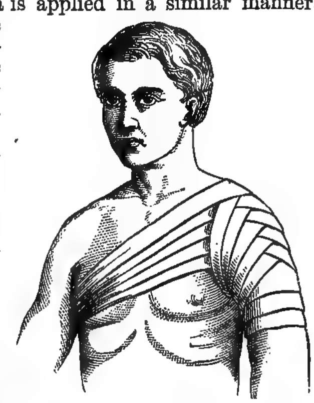


Fig. 388.—Ascending Lateral Spica of the Shoulder. (After Fischer.)

arm once more. The figure-of-8 turns cross each other from below upward, and the spica is, therefore, an ascending one (see Fig. 388). Of course, a descending spica is applicable to the shoulder as well as to the hip, but the ascending one, as here described, is usually to be preferred. If the student practises making a lateral spica until he becomes perfectly familiar with it, he will experience no difficulty in deflecting the roller a little sooner or a little later, so as to make an anterior or a posterior spica.

THE UPPER EXTREMITY. — After making a few turns around the wrist, the roller is carried obliquely across the dorsum of the hand to the roots of the fingers, and then proceeds upward in simple turns and reverses until the thumb is reached; here a few figure-of-8 turns are made, and then the wrist is covered by a dolabra currens, and the forearm and arm by reverses (Fig. 389). If the elbow is swollen or flexed it will be necessary to cover it by a testudo as described for the knee. When it is desired to bandage each finger separately, a narrow bandage (one inch) is necessary. This is first passed two or three times around the wrist, is then carried directly across the dorsum of the hand to the root of the finger, and, by a dolabra repens, to the tip; here its course is turned back, and by a few simple turns and reverses the finger is covered. The roller, arrived once more at the root of the finger, is carried directly to the wrist, and a couple of figure-of-8 turns between the wrist and finger are made; then it is carried to the next finger, where the same manœuvres are repeated (see Fig. 390). The shoulder is covered by a spica, as before described.

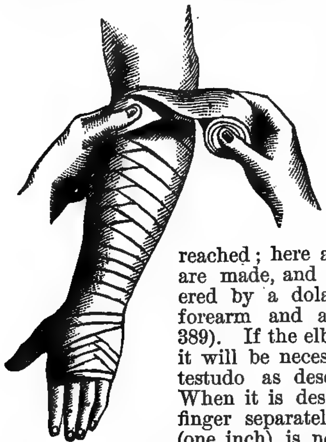


FIG. 389.—Bandage of the Forearm. Showing also the method of making reverses. (After Fischer.)

The preceding description applies to the method of bandaging most commonly employed, but for applying a roller to a limb the writer prefers a somewhat different procedure. A beginning is made as in the ordinary way, by a few turns around the ankle or wrist, but when the bandage begins to run up the limb it is not arrested on the anterior surface, but passes posteriorly and is there reversed. It then returns to the front in a descending line, passes around the limb once more, without a reverse, and again ascends over the anterior surface, is reversed behind, and descends as before. This is a combination of the figure-of-8 with posterior reverses. A bandage thus applied presents a much neater appearance, and is less liable to become disarranged than is one put on in the ordinary way with anterior reverses. It can usually also be continued over the knee or elbow without the necessity of resorting to the testudo. The writer has never seen this method described, and does not know where or by whom it was devised. After a bandage is applied it should be caught by a few stitches along its anterior surface in order to prevent slipping of the folds.

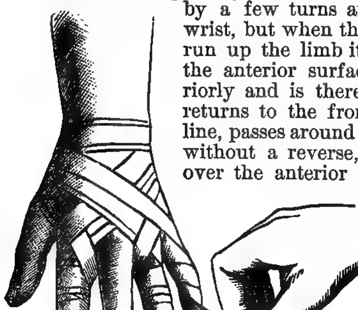


FIG. 390.—Bandage of the Fingers. (After Fischer.)

The head may be neatly covered by a roller bandage, but the cap so formed is very easily disarranged, and is practically of little service. In applying this bandage (Mitra Hippocratis) a double-headed roller is used; this is one which is rolled from each end, the two heads lying on the same side of the bandage and being of equal size. One roll being taken in each hand, the intervening strip is applied low down over the centre of the forehead, and thence the bandage is unrolled on either side until the two heads meet posteriorly below the occipital protuberance. From this point the two rolls are applied in different directions, one passing continuously around the head in a circle, the other forward and backward over the cranium; passing beneath the circular turn, it is brought back in the line of the sagittal suture to the forehead; here it is again crossed by the opposite roll and then returns to the occiput a little to the right of the centre of the first fold; held here again by the circular turn it is folded over and returns to the forehead through a corresponding line on the left side; and so on until the cranium is entirely covered (see Fig. 391). A single-headed or ordinary roller may be used in a similar way. After a couple of circular turns are made, the bandage is reversed and carried backward and forward over the head several times, each turn slightly overlapping the preceding, and diverging to the right and left from the median line. The folds in front and behind are kept from slipping by the fingers of an assistant. Then two or three more circular turns are made to steady the folds, and the backward and forward reverses are repeated. A few stitches, or a couple of pins, will serve to fix the folds more securely. After the head is covered another circular turn completes the bandage. This is the ordinary recurrent bandage of the head, sometimes called the capelline.

FIG. 391.—Mitra Hippocratis. (After Fischer.)

The bandage just described is more frequently employed for the stump of a limb after amputation, being in this case also called a recurrent bandage. The knotted bandage, occasionally used to make pressure over the temporal artery, is applied with a double-headed roller. Beginning on the side opposite to that at which pressure is to be made, the two rolls are carried around the forehead and occiput, respectively, meeting over the temple; here they make a half turn around each other and are carried over the head and under the chin, passing completely around and meeting again at their point of departure, where they are once more deflected one around the other and assume their original direction (see Fig. 392).

FIG. 392.—Knotted Bandage. For compression of the temporal artery. (After Fischer.)

Two more applications of the roller bandage may be mentioned, namely, the suspensory bandage of the breast and Velpeau's bandage for fractured clavicle. The single suspensory of the breast is a modified spica of the shoulder, the axillary turns of the opposite side being so made as to support and envelop the mamma. The double suspensory is really a double spica of the breast, the roller passing from one shoulder, say the right, to the base of the opposite, left, mammary gland, across the back, around the base of the right mamma, up to the left

shoulder, across the back to just below the right axilla, around the chest, and up again across the back to the right shoulder whence it started. This journey is repeated five or six times, and the bandage is completed (see Fig. 393). Velpeau's bandage is intended to keep the arm in such a position that the elbow shall be opposite the ensiform cartilage, the hand resting on the opposite shoulder. The bandage passes across the chest, up the back to the affected shoulder, down the arm, under the elbow so as to make a sling, up to the opposite axilla, around the body and up the back again to the affected shoulder, as shown in Fig. 394. This bandage is now seldom employed, much greater security being obtained by strips of adhesive plaster. There are various other purposes to which the roller bandage may be applied, viz., to hold back the shoulders, to keep the head flexed upon the chest or extended, etc.; but we need not stop to consider these at length, as they are but modifications of the different procedures already described.

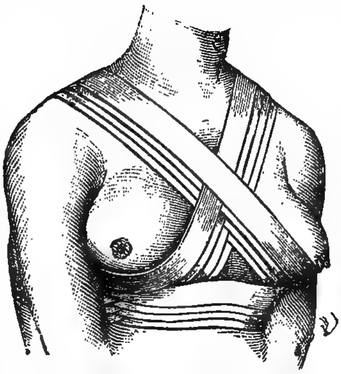


Fig. 393.—Suspensory Bandage of the Mammæ. (After Eulenburg.)

The bandage of Scultetus, or many-tailed bandage, is one that possesses peculiar advantages in certain cases in which movements of the limb are to be avoided as far as possible, and in which, at the same time, a frequent inspection of the surface is desirable. It is made of a number of strips, cut of a suitable length, and arranged in parallel rows overlapping one another for about one-third of their width. They are retained in position by a longitudinal strip applied along the central portion and held by a few stitches. The mode of application of the bandage is represented in Fig. 395. If the pieces are simply laid in position and not attached to a longitudinal strip, it will be possible to replace soiled parts without removing the entire bandage. The bandage should be unfolded, and a clean strip can then be pinned to the soiled one and drawn under the leg at the same time that the old piece is removed. A T-bandage is made of two strips attached to each other at a right angle. It is used to retain dressings of the perineum and of adjacent parts. The portion representing the arms of the T is tied around the body, while the upright strip passes under the perineum and is attached to the body part in front. The perineal strip may be slit into two portions for a sufficient distance, one part passing up on each side of the genital organs.

Fig. 394.—Velpeau's Bandage. (After Fischer.)

Fig. 396 represents a four-tailed bandage for the chin. It is made of a strip of wide bandage, slit up at each end. The central portion is placed on the chin, the tails crossing each other and being tied or pinned above and anteriorly, as shown in the figure. It is sometimes called the funda maxilla.

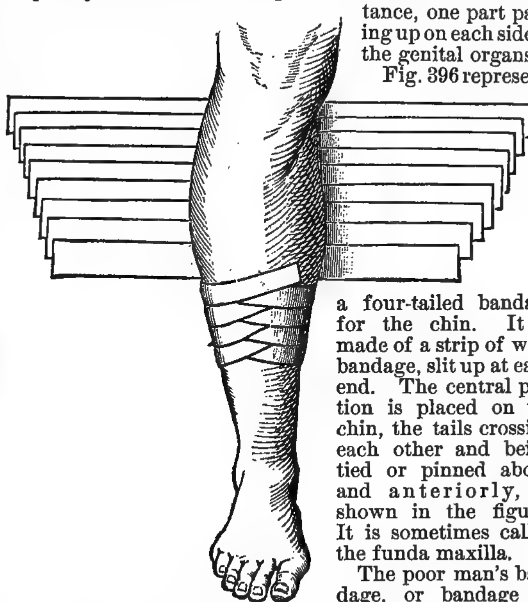


Fig. 395.—Bandage of Scultetus, or Many-tailed Bandage. (After Hueter.)

The poor man's bandage, or bandage of Galen, is a six-tailed bandage used to cover the head (see Fig. 384). An oblong piece of cloth, wide enough to extend from just above the eye-brows to a little below the occipital protuberance, is cut at each end into three strips, leaving a central portion about four inches in width. The two central strips are brought under the chin and then tied or pinned, while the posterior strips are brought forward and the anterior ones backward, and are pinned together over the temples.

In 1832, Mayor, of Switzerland, published a monograph,[1] in which he described a great variety of ways of applying ordinary handkerchiefs, or pieces of cloth of different shapes, as retentive bandages. These were used as caps, as slings for the arm, as suspensories of the breast or scrotum, as coverings for stumps, etc. Square, oblong, and triangular cloths were used, and a great amount of ingenuity was exercised in applying them to various portions of the body. It is unnecessary to enter into any detail in the description of these different bandages, for they are of use in only a limited number of cases.

Fig. 396.—Funda Maxilla, or Four-tailed Bandage of the Chin. (After Jaccoud.)

Fig. 397, shows the method of applying a triangular bandage to an amputation stump, and will serve as an

illustration of the mode of application of similar cloths to the head, foot, hand, etc.

Roller bandages may be impregnated with starch, silicate of soda, plaster-of-Paris, etc., and when applied,

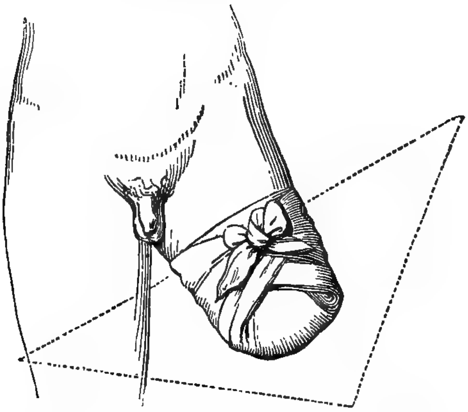


FIG. 397.—Triangular Bandage of a Stump. (After Jaccoud.)

make a light and strong splint for the part which they surround. The description of these dressings will be given under their appropriate titles.

Thomas L. Stedman.

[1] Bandages et Appareils à Pansements, ou Nouveau Système de Déligation Chirurgicale, Paris, 1832.

BARBADOS. The Island of Barbados (also spelled Barbadoes) lies furthest to windward, *i.e.*, to the eastward, of any of the Windward Islands, in Lat. 13° 4′ N., Long. 37° W. For nearly three hundred years the island has been in the possession of the English Government, and Bridgetown, its capital and largest town, is one of the chief commercial centres of the West Indies. The annual sugar crop of Barbados is estimated at about forty thousand hogsheads, and the whole island is under cultivation, the population being very dense (nearly a thousand per square mile). The length of the island, from north to south, is about twenty-one miles, and at its broadest part it extends some fourteen and a half miles from the eastern, or windward, to the western, or leeward, shore. "Barbados presents every variety of scenery—hill and valley, smooth table-land, and rugged rocks. From one point of view the land rises in a succession of limestone and coral terraces, which indicate different periods of upheaval from the sea. From another there is nothing to be seen but a mass of abruptly-rising rocks. The highest elevation, Mount Hillaby, is 1,104 feet above the level of the sea. The island contains but few streams or streamlets. The gullies or ravines—the result, no doubt, of volcanic agency—are, however, very numerous, radiating from the high semicircular ridge of the coralline formation in a very regular manner to the west, north, and south, but not to the east, where the coral rocks end abruptly. . . . The climate of Barbados is healthy; the temperature equable. For eight months in the year the sea-breezes keep it delightfully cool for a tropical country. The extent of cultivation, the absence of swamps (the porous character of the rock immediately underlying the soil preventing accumulations of stagnant water), account for the freedom from miasma." (Encyclopædia Britannica.) "The northeast trade-wind prevails throughout three-fourths of the year, and the rains also come for the most part from the northeast; but at certain times of the year the wind shifts to the southwest and northwest, bringing showers which, however, do not extend across to the windward, or northeast, side of the island. Indeed, it is only exceptionally that rain coming from any direction falls at one and the same time throughout the entire extent of the island. March is the driest month, October the most rainy. . . . During the dry season, December to June, the lowlands on the leeward side of the island have a smaller rainfall than do the other districts; but during the wet months (July to November), when the westerly winds are of most frequent occurrence, the rainfall of these districts exceeds that of other portions of the island." (Hann's "Handbuch der Klimatologie," p. 356.)

The average rainfall for each of the twelve months of the year is given in a table to be found on p. 349 of the work just quoted; the figures being as follows:

January	3.267 inches.	July............	5.708 inches.
February	2.605 "	August	7.244 "
March..............	1.456 "	September...........	6.221 "
April...............	2.007 "	October.............	8.766 "
May................	3.543 "	November	7.086 "
June	5.433 "	December	4.487 "
Year...........................	57.757 inches.		

As we learn from the figures of this table, the total rainfall in Barbados for the six months of December, January, February, March, April, and May is only 17.36 inches, or an average amount of but 2.89 inches per month. The temperature in Barbados, as in all other tropical islands, varies but little throughout the year. According to the writer in "Appleton's Handbook of Winter Resorts," the thermometer ranges in December from 73° F. to 85° F., and in February, from 71° F. to 84° F. A letter from the Superintendent of the Canadian Meteorological Service, which was kindly obtained for the writer by the Hon. Beaumont Small, of Ottawa, in reply to inquiries concerning the climatological statistics of the British West Indies, alludes to the climate of Barbados as follows:

"The mean monthly temperature ranges from 76° F. in January to 80.8° F. in August. The rainfall varies greatly from month to month, but is never wholly absent; the total yearly amount, from an average of twenty-five years, was 57.74 inches. The average for March exceeds two inches, and in October reaches nearly eleven inches, these being respectively the driest and wettest months of the year."

Dr. Weber (in Ziemssen's "Handbuch der Allgemeinen Therapie") speaks, concerning the benefit derivable by phthisical patients from a winter residence in Barbados, as follows: "Winter residence in Barbados is said, by R. H. Bakewell (*Practitioner*, vol. xxi., 1878), to be favorable to cases of phthisis. I myself have had experience of its effects upon only four cases of the disease in its first stage, and upon one case in the beginning of its second stage. In two instances the result was favorable; in two others, the disease progressed; in one, it remained stationary, while the patient improved in general condition."

For more general discussion of the advantages and the disadvantages of a residence in a place possessing such a climate as is that of Barbados; of its desirability or undesirability as a health resort for consumptives; and for the proper determination of the question as to what invalids should be recommended to resort thither, the reader is referred to the articles on Climate, on Health Resorts, on the West Indies, on Phthisis, etc., which are to be found elsewhere in this HANDBOOK.

Huntington Richards.

BARBERRY (*Berberis ou Épine vinette*, Codex Med., *Berberis vulgaris* Linn.; Order, *Berberidaceæ*) is a well known shrub, from one to four metres in height (3 to 12 feet) with clustered stems, and yellow wood. Its dimorphous leaves—one set of sharp-branched prickles, and the other oval prickly-serrate in axillary rosettes—its drooping racemes of yellow flowers with sensitive stamens, and its long, red, sour berries, make its recognition particularly easy. It is a native of Europe, but naturalized in most temperate countries, occasionally planted for ornament or hedges, but too easily grown, and in general a troublesome pasture weed.

The ripe berries contain sugar, and more than six per cent. of *malic acid*, and are made into jam or syrup for domestic use. The syrup, diluted, forms a refreshing drink of the tamarind and raspberry vinegar type. The bark and wood have long been recognized as tonic; they

are similar in qualities, but the bark of the root is preferred in this country. It is usually in narrow, longish whittlings, having been pared from the wood with a knife; of a yellowish-gray color externally, and yellow within, fading with time and exposure to light. The odor is bitter and disagreeable, the taste intensely and persistently bitter. The most characteristic constituent of barberry is the alkaloid *berberine*, which exists in it to the extent of "nearly twelve per cent." (Hager) in the form of hydrochlorate. This substance was first observed in *Geoffroya jamaicensis* Murray, by Hüttenschmidt, and called "*Jamaicin;*" afterward in species of *Zanthoxylum* by Chevallier and Pelletan, and described as *Zanthopicrit;* and finally in barberry in 1835, by Buchner. The identity of these different discoveries has been only recently proved. Since its discovery in barberry it has been found in a number of other plants, even in several different orders. Pure berberine crystallizes with nineteen per cent. of water, in bright, shining, yellow needles; melts easily, and dissolves, like all alkaloids, freely in alcohol; it is but little soluble, however, in cold water, but more freely so in hot water. The solution has a neutral reaction, and an exceedingly bitter taste. Berberine unites with acids, forming crystallizable yellow or orange salts. A second alkaloid, *Oxyacanthine* (Vinetine), which is white and forms white salts, also exists, but only in very minute quantity.

Barberry and other plants containing these alkaloids as their chief constituents, are in general bitter tonics, when given in small doses increasing the appetite, and improving the digestion. They are often given, especially in warm countries, with this effect in mind, after fevers, and during debilitating diarrhœas. Sometimes also as antiperiodics, but for this use they have but little value. Berberine itself has been used for the same purposes. In animals it has been observed to produce diarrhœa and paralysis of the posterior extremities, but these effects have not been observed in man even after very large doses (of several grammes). *Oxyacanthin* appears to be more active than berberine, but its quantity is so small in barberry root that it can, with safety, be ignored.

Dose of barberry root bark, as a tonic, from one to three grammes (1 to 3 Gm. = gr. xv. ad xxxv. or xlv.) in tincture or acidulated infusion; of berberine, from one to three decigrammes (0.1 to 0.3 Gm. = gr. jss. ad v.).

ALLIED PLANTS.—The order contains about one hundred species, of which more than half belong to the typical genus *Berberis,* comprising yellow-wooded shrubs or trees in all parts of the north temperate zone. Besides the common barberry, a dozen more have been in use, among them the following: *B. aristata* D. C.; *B. Lycinus* Royle; *B. Asiatica* Roxburgh, etc., all Asiatic shrubs used in China and India for diarrhœas, fevers, etc. An extract made by the aborigines from the roots of one or more of them, was in use as long ago as the beginning of the Christian era, and was imported into Europe at that time, principally for ophthalmic diseases, for which it has always maintained a reputation. *B. Aquifolium* Pursh., the Oregon grape-root of the Rocky Mountains, is a recent applicant for favor. All the above have similar qualities, and owe their principal value to the same alkaloid. Besides the above the order contains *Podophyllum* and *Caulophyllum,* which have not the same action. The neighboring orders, *Ranunculaceæ* and *Menispermaceæ,* contain also berberine-yielding members, as *Hydrastis, Xanthorrhiza, Coptis,* and *Jateorrhiza* (Columbo).

ALLIED DRUGS.—For a list of bitter tonics, see GENTIAN. Several other alkaloids in small doses are also tonics, such as quinine and its associates, strychnine, etc.

W. P. Bolles.

BARIUM. Salts of barium are of more interest to the physician from the point of view of toxicology than from that of therapeutics. Barium compounds are all poisonous, the soluble ones, of course, more actively so than the insoluble. Therapeutically, barium has been assumed to have a power over scrofulous conditions analogous to that of iodides or of mercurials, but no striking results have ever been demonstrated from its use. The *chloride* is the only baric salt of medicinal interest.

Baric Chloride, $BaCl_2$, $2H_2O$. Baric chloride is not now officinal in the United States Pharmacopœia. It is a white, crystalline salt, occurring in rhombic tables, permanent in the air. It dissolves freely in water and diluted alcohol, and has a bitter, disagreeable taste. It has been given medicinally in doses of from 0.03 to 0.13 Gm. (one-half to two grains), dissolved in an abundance of water.

Edward Curtis.

BARIUM SALTS. TOXICOLOGY.—Several of the soluble salts of barium, especially the nitrate $Ba(NO_3)_2$ and the chloride $Ba\,Cl_2$ are used largely in the chemical laboratory as tests for sulphuric acid. The only compound, however, which is familiar in commerce is the sulphate $Ba\,SO_4$, which is known as *barytes* or *heavy spar.* This is a heavy, white, opaque substance, much employed as a general adulterant on account of its weight, but especially for mixing with and adulterating paints. Its high degree of insolubility deprives it of any specific poisonous action, except possibly as a mechanical irritant. It has been stated that it has been used in flour, and even in butter, but such use must be rare.

The soluble barium compounds, especially those above mentioned, are irritant poisons. Cases of poisoning by them are, however, rare, and have been mostly the result of accident, the body having been mistaken for one of the ordinary saline cathartics. An English observer has asserted that barium chloride is analogous to corrosive sublimate, but is certainly not so active a poison.

In the recorded cases of poisoning by barium salts the quantities taken have usually been rather large, varying from one hundred grains to half an ounce. The symptoms—which do not arise immediately—are those of irritant poisoning, nausea, with sharp burning pains in the stomach, followed by vomiting and purging. Loss of muscular power has been noted in some of the cases, but most have exhibited convulsions toward the end. No characteristic brain symptoms are developed, but giddiness and headache have been observed.

Post-mortem examination shows the usual appearances of irritant poisoning, inflammation of the mucous membrane of the stomach and bowels, and extravasation of blood.

Death has usually occurred in less than twenty hours, in some cases even in two hours.

Barium carbonate is used as a rat poison, but a case is on record to show that it is not a very virulent body.

The antidote in poisoning by barium salts is any soluble sulphate, the proper ones being Epsom salt, Glauber's salt, or alum. These form at once the highly insoluble and inert barium sulphate, which can then easily be removed from the stomach by promoting the vomiting. The poison will be completely neutralized by the antidote, and the subsequent treatment will be on general principles.

There is no difficulty in recognizing a barium salt. Sulphuric acid or any soluble sulphate produces at once an opaque, white precipitate of barium sulphate. It is farther distinguished by its entire insolubility in water, in acids, or in alkalis.

Henry Leffmann.

BARTHOLIN'S GLAND. ANATOMY AND PHYSIOLOGY.—Bartholin's gland was described by a number of the old anatomists, including Bartholin, Duverney, and Cowper, all of whose names have been attached to it by different writers. In recent years it has been studied more particularly by Tiedemann and Huguier, the latter of whom gave it the name of the vulvo-vaginal gland.

These glands, of the compound racemose order, are two in number, situated one on either side of the introitus vaginæ, immediately below the bulb of the vestibule, in a space bounded by the superficial perineal fascia in front, the vagina internally, and the ascending ramus of the ischium externally. Each gland is bean-shaped, usually not more than half an inch long, but sometimes (especially in prostitutes) as large as an almond. When in its normal condition it is not generally to be felt on palpation, but the mouth of its duct, of a size sufficient to admit a bristle,

may commonly be seen at the bottom of the furrow which separates the ostium vaginæ from the lower end of the labium minus. The duct is rather more than half an inch long. According to Tiedemann, the gland may wholly disappear in advanced age.

The accompanying illustration (Fig. 398), from Huguier, shows a dissection of the parts in the immediate neighborhood of Bartholin's gland, while the second cut (Fig. 399), taken from Henle, shows a front view, in section, of the external genitals of a new-born female infant, in the region of the posterior commissure of the labia pudendi (left half of the posterior cut surface).

FIG. 398.—The Vulvo-vaginal Gland and its Excretory Duct. (After Huguier.) *a*, *a*, Section of the labium majus and nympha; *b*, the gland; *c*, its excretory duct; *e*, its orifice in the vulvo-caruncular furrow; *f*, the bulb of the vagina; *g*, the ischio-pubic ramus.

The gland is considered to be the analogue of Cowper's gland in the male. It furnishes a whitish mucous secretion, the purpose of which is to lubricate the vulva in the act of coitus. This secretion is sometimes ejected in a jet, as the result of titillation of the vulva or erotic excitement, in the waking state or during sleep.

PATHOLOGY.—Affections of the vulvo-vaginal gland and those of its excretory duct, taken together, are exceedingly common. In general, it is the duct alone that is affected, at least in the first instance. Common inflammation, which is apt to end in the formation of pus, is the most important of these diseases, and inflammation may be the cause or the consequence of a distention of the duct due to retained secretion.

Dilatation of the Excretory Duct.—This condition, the so-called retention-cyst, is undoubtedly often mistaken for a swelling of the gland itself, but its comparatively superficial situation is sufficient to distinguish it from the latter. Unless accompanied by inflammation or œdema of the surrounding tissue of the labium, it ought not to be confounded with any other affection, and, even when one of those complications is present, it requires to be diagnosticated only from hæmatoma and from a seropurulent form of infiltration of the labium that sometimes takes place during the lying-in period. It may be distinguished from hæmatoma by the fact of its gradual formation, and, less readily, from puerperal infiltration by the same feature, which, however, becomes very significant when coupled with the patient's general condition and the history of the case.

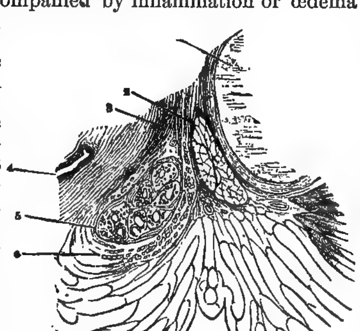


FIG. 399.—1, A section of the lower part of the descending ramus of the pubic bone; 2, the ischio-cavernosus muscle; 3, the bulbo-cavernosus muscle (in longitudinal section); 4, the vagina; 5, Bartholin's gland; 6, the bulbo-cavernosus muscle (in oblique and transverse section); 7, the labium pudendi.

The affection is most common on the left side—its immediate cause being an obstruction at the orifice of the duct; the conditions leading to the latter occurrence are various. It is very common in newly-married women and in prostitutes, which fact tends to show its frequent origin in a sort of traumatism due to excessive coitus. Gonorrhœa, also, may readily give rise to it, or any catarrhal affection of the vulva, including eczema. Besides, the urine may be of so irritating a quality as readily to set up quite enough irritation at the mouth of the duct to lead to obstruction. Another cause mentioned by writers is the encroachment of condylomata upon the opening of the duct.

This form of disease tends to induce acute inflammation, and, if this does not occur, it is prone to relapse. The swelling is not always painful in itself, but it constitutes a certain impediment to coitus, and is always a source of annoyance to the patient.

Very commonly the retained secretion may be squeezed out through the orifice of the duct, and in some instances no further obstruction takes place for a considerable length of time. In general, however, dilatation by means of graduated probes is required. If this proves ineffectual or unusually difficult, it is best to cut into the swelling and pass the probes from the wound. In this case the cavity should be dressed antiseptically. When repeated relapses occur, a portion of the wall may be cut out and the remainder of the cavity cauterized, with a view of inducing suppuration and obliteration. Tincture of iodine or nitrate of silver will usually answer the purpose, but in stubborn cases good results have been secured with chloride of zinc.

Deeper-seated retention-cysts, due to obstruction of the radicles of the duct within the gland itself, are much less common. In some instances they reach a very great size, extending down on the perinæum and up by the side of the vagina, so high even as to press the uterus out of its natural situation, and they may be complicated with an effusion of blood into the cavity. In their treatment, obliteration should be the aim, and the means to be used are the same as have already been mentioned.

True inflammation, either of the gland or of its duct, commonly ends in suppuration, and the pain is apt to be severe, with some constitutional reaction. The abscess usually breaks on the inner side of the labium, giving exit to dirty, stinking pus. It is to be treated like ordinary abscesses; at first with poultices, and, when fluctuation is evident, by means of a free opening, preferably on the inner aspect, and the cavity should be stuffed with antiseptic cotton. When the abscess is left to itself several openings may form, fistulous tracts may remain for a long time, and undermining may occur, as with buboes. These features call for the same treatment as in other parts of the body.

Pain and hyperæsthesia of the gland are said to be the occasional result of the repeated discharge of its secretion, in consequence of erotic dreams. *Frank P. Foster.*

BASIL (*Basilic*, Codex Med.). *Ocimum Basilicum* Linn.; Order, *Labiatæ*, the common garden basil, is an annual Asiatic mint, cultivated in kitchen gardens in Europe and America. It is from thirty to fifty centimetres high, with branched quadrangular stems, and ovate or oblong serrated leaves. The flowers are usually in clusters of six, with an irregular calyx, having the upper lobe large, ovate, and decurrent. The corolla tube is very short; the stamens four, and declined. In fruit the calyx is reflexed. The plant has a mint-like and agreeable odor. The drug consists of the dried herb, and consequently answers to the above description. It contains about one and a half per cent. of *essential oil*, consisting mostly of a stearoptene basil-camphor, which readily crystallizes in the oil upon standing in the cold.

The use of basil is culinary rather than medical; it has the carminative qualities of the order, and may be used for the same general purposes. Its chief use is as a flavor. Dose of an infusion, *ad libitum*; of the oil, from two to five decigrammes (0.2 to 0.5 Gm. = ♏. iij. ad ♏. viij.).

ALLIED PLANTS.—See PEPPERMINT. One or two other species of *Ocimum* are used in warm countries; their qualities are those of mints in general.

ALLIED DRUGS.—The mild essential oils and the drugs which yield them. *W. P. Bolles.*

BATH, a city of over sixty thousand inhabitants, situated in Somersetshire, England, at an elevation of only one hundred feet above the sea, and containing a number of

thermal springs. The town is built chiefly on the right bank of the river Avon, and lies in a natural amphitheatre sheltered from the north and east winds. The climate is mild and equable, the mean annual temperature being about 50° F. The waters are the warmest of any in England, having a temperature of 104° to 120° F., and contain chiefly sulphates of lime and magnesia. The composition of King's well, according to the analysis of Merck and Galloway, is as follows: Each imperial gallon contains, of solids expressed in grains, calcium carbonate, 8.820; magnesium carbonate, 0.329; ferrous carbonate, 1.064; calcium sulphate, 80.052; potassium sulphate, 4.641; sodium sulphate, 19.229; sodium chloride, 12.642; magnesium chloride, 14.581; silica, 2.982; iodine and manganese oxide, traces. Total solids, 144.34 grains per gallon. There is also some free carbonic acid. The taste is not disagreeable. The waters are used in baths, and are also taken internally. The baths are usually taken every other day, the temperature of the water for most cases being reduced to 95° F. There are six principal thermal establishments, namely, King's, Queen's, Cross, Abbey, Hot, and Grand Pump-Room Hotel. The oldest of these is King's bath, which dates from the year 1236. In addition to these establishments there are also several hospitals for those whose slender means would otherwise debar them from the benefits of the baths. Chief among these are St. John's, founded in 1174; St. Catharine's, the Royal United Hospital, Bellot's, and the Mineral Water Hospital. Of course, these are not all reserved exclusively for strangers frequenting Bath, but provide as well for the ordinary medical and surgical needs of the poor resident in that city.

A course of the waters at Bath is often productive of much good in the case of sufferers from chronic constipation and hypochondriasis, and is especially valuable in the treatment of chronic lead-poisoning. The waters are also beneficial in diseases of the liver, rheumatism, gout, sciatica, and other forms of neuralgia, hemiplegia, progressive muscular atrophy, chorea, and eczema and other skin affections. They are said also to be productive of good in leprosy. The baths are taken throughout the year, but the "season" embraces the winter months. Bath is classed among the simple thermal springs.

T. L. S.

BATH ALUM SPRINGS. *Location and Post-Office*, Bath Alum, Bath County, Virginia.

Access.—By way of Millborough, a station on the Chesapeake & Ohio Railroad, 176 miles northwest of Richmond, thence by stage to the springs, 10 miles distant.

Analysis.

	No. 1. A. A. Hayes, M.D. *Grains.*	No. 2. A. A. Hayes, M.D. *Grains.*
Chloride of sodium	0.022	.....
Sulphate of potassa	....	0.032
Sulphate of magnesia	0.352	0.160
Sulphate of lime	0.476	0.317
Protoxide of iron	1.814	2.722
Alumina	1.286	1.536
Crenate of ammonia	0.232	0.222
Silicate of soda	0.253	0.394
Sulphuric acid (free)	0.726	0.985
	5.161	6.368
	Cub. in.	Cub. in.
Carbonic acid gas	1.4	1.0

Therapeutic Properties.—The presence of alumina and iron gives to these waters mild astringent and tonic properties. In composition and in their therapeutic effects they are very similar to the water of the celebrated Rockbridge Alum Spring. Skin and mucous membrane diseases are cured, or greatly relieved, by these waters, when taken in moderate doses. The accommodation for guests is ample in hotel and cottages, and the location is in the highest degree desirable.

G. B. F.

BATHS. A *bath* is the exposure of the body to some medium to which it is unaccustomed, or else to one to which it is accustomed but which is applied in an unusual manner. Baths may be taken in air, water, mud, sand, etc. They may be given for the purpose of cleanliness, of applying a fixed temperature to the surface of the body, or of introducing certain medicinal substances into the economy.

Generally speaking, baths are of water, the temperature of which ranges from 32° to 120° F., according to the effect which we desire to obtain. Within this range they have been divided as follows: 32° to 60° F., cold; 60° to 75° F., cool; 75° to 85° F., temperate; 85° to 92° F., tepid; 92° to 98° F., warm; 98° F. and above, hot.

When one enters cold water there is a shock and gasp for breath, with a feeling of cold which may induce cramps of the voluntary muscles, temporary loss of speech, and contraction of the skin, pinched features, and blueness due to checking of the circulation. If the bather be vigorous, this state of partial collapse soon yields, and these symptoms are succeeded by a glow, the breathing and pulse again become regular and full, and the person feels active and well; but if the temperature of the water be low, the previous feelings again recur after a time, the teeth chatter, the extremities show the shrivelled look of washerwomen's fingers, and a feeling of weakness supervenes. If the bather remains in the water till this occurs, it will be a long time before reaction comes on; but if he leaves it during the second period, reaction will take place quickly, and he will soon be warm, the blood returning to the skin will give it a fine glow, and there will be a feeling of lightness and vigor that is quite refreshing. The length of these periods varies greatly with the physique and habits of the bather. If the body of the bather is completely and constantly submerged he will not be so much chilled as when he is partly or occasionally exposed to the air, when evaporation may go on more rapidly.

Observations made by James Currie, M.D., on a healthy man plunging into salt water (one to twenty-four) at 42° F. in the open air, showed that in one minute his temperature fell to 90°, and in seven minutes rose to 94° in the mouth; it remained at about this point as long as he continued in the bath. After emerging from the bath the most efficient mode of warming him seemed to be by applying heat to the pit of the stomach. After coming out of the cold bath into cold air there was another fall of temperature, and on entering a warm bath a still further fall. The cold bath being in the open air gained little in heat, rising one degree in twelve minutes and three in forty-five minutes.

The same man, on going slowly into fresh water, lost heat gradually for thirty minutes, when his temperature was 93° F.; on emerging from the bath he was a long time recovering his heat, and subsequently felt sick and feeble, and had pains through his body.

Where the cold bath is suited to the person, and is not too long continued, it is tonic and bracing; it improves the appetite and renders the bather less susceptible to cold or changes of temperature. But if reaction be not prompt and complete the effects are injurious; this reaction is less apt to occur when the body is exhausted from over-exertion or illness; also in infants or the aged. If the body be bathed in perspiration from exertion, and has begun to cool at the time of plunging into cold water the effect is apt to be injurious, while the same is not so true in case of passive sweating, as in the Russian or Turkish bath. Roman youths plunged into the Tiber when in a glow from exercise, but Alexander nearly lost his life from plunging into the Cyanus when exhausted by a long march.

If the bather shivers, has uncomfortable feelings in his head, and does not react, the baths should not be continued.

When there is physical exertion at the time of the bath, there is less suffering from cold. This is generally the case with sea baths, in which the effort to keep the feet and the striking of the waves against the person stimulate the circulation. And yet, even here, the bather is less apt to get chilled if he keeps his body under water In cases of shipwreck those who are deep in the water outlive those over whom the waves dash.

The existence of disease of the heart or arteries contra-indicates plunging into cold water or taking cold shower-baths. When recommended for the first time, cold baths should be tried with caution, and close attention should be paid to the temperature of the water and the duration of the bath. After a time the patient may, perhaps, increase the length of his baths. Sea baths are best taken about three hours after eating, and the next meal should not be eaten till reaction is fully established.

Ordinarily the cold bath is taken immediately on rising, while one is warm, from the bed, and the body is then rubbed well with a harsh towel.

The cool bath has similar effects in less degree, and is the proper one for infants or aged persons when the tonic effect is desired.

Warm baths do not induce shock, but cause a comfortable sensation; the vessels of the skin fill up and the body feels larger. After fatigue or prolonged exposure to cold, they may be resorted to with benefit and pleasure. Tepid baths were used by the ancients for fatigue and fever. Homer describes them as given by hosts to their guests; in such cases they were followed by inunction.

Newly born infants should be bathed in water about 98° F., and after being cleansed they should be quickly dried and warmly dressed.

When the tonic effect of baths is desired for children, it is well to add rock salt to the water, and in many cases it is preferable to give merely air baths; exposing the body to the air of a moderately warmed room, while gentle friction is applied with the hand. This is also beneficial for adults who are not sufficiently robust for cold-water baths. During the exposure the patient may exercise with light dumb-bells, or by rubbing with coarse towels.

Hot baths induce perspiration, and are useful when the skin or kidneys are inactive and unequal to carrying off the waste that should be removed by them. When the sweating has continued long enough (before exhaustion occurs) it may be arrested by a cold shower, or a plunge in cool water; otherwise there is danger of "taking cold." Vapor baths may be given at a temperature of from 110° to 130° F. or more, according to the amount of water in the vapor. As evaporation goes on rapidly in dry air, the drier the air the higher the temperature that may be borne. Persons may remain with comfort in very dry air of 212° F. or more—even up to 300° F. it is said; the body being kept cool by evaporation of the perspiration.

Vapor, as well as water baths, may be medicated with various substances; such baths are more particularly resorted to in chronic diseases. They are often extemporized by seating a patient on a common chair, placing a pan containing the substance to be vaporized over an alcohol lamp under this chair, and covering patient, chair and all, with an impervious blanket or covering, and keeping the lamp burning till profuse sweating occurs. Tar, sulphur, mercury, and other substances, are applied in this way.

By "graduated bath" is meant a bath in which the temperature of the water, at the time of immersion, is from 90° to 100° F., and is gradually lowered 25° to 30° F. in the course of a half hour. As soon as the patient begins to feel chilled he is to be removed from the bath.

For the effect of baths in disease, see the article on Balneotherapeutics. *Charles E. Hackley.*

BATHS IN DISEASES OF THE SKIN.—Under this head only the influence of water and its vapor, or of substances in watery solution, is to be considered. The effects produced by baths upon the skin are of several kinds. In the first place, the temperature of the bath without regard to its contents has a certain effect, while the influence of water alone, or of substances which may be dissolved in it, may produce either a local effect, or, in the latter case, may bring about constitutional changes according to the medicinal agent employed.

Lukewarm and moderately hot baths diminish irritability of the peripheral ends of the sensory nerves. For this reason, such baths are useful in those skin diseases in which pruritus is a prominent symptom. General pruritus of an idiopathic character is nearly always relieved by the use of warm baths, which should, in most cases of the disease, precede the application of the more decided anti-pruritic remedies. The addition of "indifferent" substances, as starch, bran, oat or corn meal serves to soothe the inflamed skin in eczema, particularly where this has been broken, leaving a moist surface. Here crude water alone sometimes irritates the skin, when the addition of some amylaceous substance soothes and relieves pain and itching. With a similar end in view, alkalies are added to baths, their soothing action being probably due to some osmotic action similar to that which takes place when carbonate of sodium solutions are used in dressing burns. In the intense dermatitis of burns and in skin affections, like pemphigus, where the patient is more or less flayed, the continuous tepid bath, as devised by the elder Hebra, offers a medium in which the patient can live without such anguish as constantly tortures him when exposed to the air, and even with some chance of ultimate recovery.

The question of the absorption, either of water or of substances dissolved in water, through the uninjured skin, is one which has been discussed for many years without any perfectly satisfactory conclusion having been reached. A great number of practical experiments have likewise been made, many, however, lacking in the necessary scientific accuracy, as has been pointed out by Leichtenstern (Balneotherapie, "Ziemssen's Handbuch der Allgemeinen Therapie," 2te Bd., 1ter Theil). The conclusions of this writer seem based on such a careful analysis of facts observed, and agree so well with what is known of the physical qualities of the cutaneous envelope, that experience seems likely to confirm them in every respect. Leichtenstern says that:

1. Imbibition of water and of salts dissolved in water may occur so far as the superficial layers of the epidermis are concerned in the bath.
2. Circumstances which favor such imbibition are warmth, duration (several hours) of the bath, removal of the fatty secretion of the skin (sebum) either by previous washing with soap, or by repeated baths, or by the addition of detergent substances to the bath.
3. The palms of the hands and soles of the feet imbibe water most readily on account of the absence of sebaceous glands in these parts.
4. Imbibition is not necessarily followed by absorption, indeed, it is probable that the water imbibed during the bath is shortly after lost by evaporation. In any case, the amount imbibed is so small as to elude estimation by weighing or otherwise.
5. Absorption, in the proper sense of the term, of water and of non-volatile substances contained therein, has never been proved to take place in ordinary baths, in spite of numerous researches and assertions tending to prove such a result.
6. Nor are the excretory ducts of the sweat and sebaceous glands so constituted as to be capable of absorption of water, although by friction a minute quantity can be pressed into these openings—not enough, however, to produce a physiological or therapeutic effect.
7. Gases and volatile matters dissolved in water can be absorbed through the skin. Sulphurous acid and free iodine are thus taken into the system in baths; while free carbonic acid is not absorbed, excepting in baths peculiarly rich in this gas, and then only in small quantities.

With these facts in view, the use of baths in diseases of the skin is to be restricted to such cases as can in reality be benefited by them. The use of warm water baths in allaying irritation of the peripheral nerves has already been pointed out. A further use is found in those more or less generalized skin diseases which are accompanied by diminution in the normal secretion of the skin, as ichthyosis, where the heat and moisture induce further secretion, and where the action of the water in macerating the rough, dry epidermis gives great relief, and prepares the way for oleaginous emollients.

The simple warm bath, or the bath containing carbonate of sodium, also finds its place in the treatment of dis-

eases accompanied by the formation of crusts and scales over a considerable area of the body. Maceration detaches these otherwise intractable masses, and prepares the diseased surface for direct medication.

The imbibition of water by the surface layers of the epidermis is taken advantage of in the treatment of parasitic diseases, particularly of scabies. Here the medicated water does certainly penetrate far enough to destroy the itch-insect and its ova, and no more penetration is needed.

The use of vapor baths to aid the penetration of medicinal substances is shown in the treatment of syphilitic eruptions by the mercurial vapor bath. Here the body, immersed in a vapor until free perspiration takes place, is in a fit condition to absorb the mercurial vapor disengaged simultaneously (see under Syphilitic Diseases of the Skin).

An apparent exception to the rule of non-absorption of salts in watery solution is found by practical experience in the treatment of infantile syphilis. A syphilitic infant, placed in a small tub of water in which is dissolved ten grains of the bichloride of mercury, will absorb a sufficient quantity of the drug to influence the system and induce a rapid improvement in all symptoms. Whether absorption takes place through the unbroken integument or through the mucous membrane of the anal or sexual orifice, I am unable to say, but the clinical fact is established that mercurial absorption takes place.

The following diseases are those in which baths may be employed at times with advantage: Erythema, urticaria, eczema, pemphigus, lichen ruber, prurigo, psoriasis, pityriasis rubra, dermatitis, purpura ?, ichthyosis, scleroderma, and the neuroses of the skin, particularly pruritus. The syphilitic eruptions of the skin, when generalized, are often relieved by mercurial baths acting locally in connection with internal treatment; while, in the case of infants, a general impression on the economy may be obtained by mercurial baths. Of course, mercurial vapor baths have a constitutional, as well as a local, effect in adults. Parasiticides, chiefly sulphur and its compounds, act favorably in the form of baths in tinea tricophytina and tinea versicolor; also in scabies. When used in pediculosis corporis, baths are chiefly useful as antipruritics; the insects causing the disease residing, as they do, in the clothing, are not destroyed by bathing. For further particulars regarding the employment of baths, reference may be made to the various articles on skin diseases throughout the present work. The following formulæ for the more commonly employed baths, may be mentioned under the present head. The temperature of these baths, it is understood, should not vary more than two or three degrees above or below 90° F., and since to obtain the full effect they should be prolonged to one-half, or even a whole hour's duration, the temperature should be kept up by the frequent addition of small quantities of warm water.

The medicated baths commonly employed in diseases of the skin are the following: The acid bath, ℞. Acid. nitric. fort., f ℥ jss.; acid. hydrochloric. fort., ℥ j.; aquæ, C. xxx.; employed in pruritus, urticaria, and papular eczema. The alkaline bath, ℞. Sodii carb., ℥ iv., aquæ, C. xxx. Another, ℞. Potassii carbonat., ℥ iv.; sodii carbonat., ℥ iij.; boracis pulv., ℥ ij. Use one such powder for a thirty-gallon bath with half a pound of starch. Employed in acute eczema, ichthyosis, psoriasis, erythema, and urticaria. A formula employed for children is the following: ℞. Pulv. boracis, ℥ j.; sodii carb., ℥ ij.; potassii carb., ℥ iij. M. Two to four teaspoonfuls for every gallon of water, with double the amount of dry starch. The creasote bath, ℞. Creasoti, f ʒ ij.; glycerinæ, ℥ ij.; aquæ, C. xxx., is employed in pruritus and in certain cases of squamous eczema. The sulphur bath, ℞. Potassii sulphureti, ℥ iv., aquæ, C. xxx., is used in psoriasis, pityriasis, acne, and impetigo, and as a specific in scabies. Another formula is the following: ℞. Sulphur. precip., ℥ iv.; sodii hyposulphit., ℥ j.; acid. sulphurici fort., f ʒ j.; aquæ, Oj., in a bath of thirty gallons. This last is employed exclusively for scabies. Sublimate baths, ℞. Hydrarg. chlor. corrosiv., gr. xlv.; ammonii chloridi, ʒ ijss.; aquæ, f ℥ ijss., in a bath of thirty gallons, is used in pruritus. The sublimate baths, which are so useful in infantile syphilis, are composed of ten grains of the bichloride of mercury to each bath in a child's bath-tub. The infant is to have a flannel skirt or other convenient cover tied about its neck and spread over the tub, to prevent splashing the water into mouth or eyes. Tan baths containing a handful of fresh tan-bark in each bath have been recommended for use in purpura. Tar baths are employed by rubbing the diseased patches with tar, and then employing an ordinary warm bath. It was much employed by the late Professor Hebra in psoriasis.

The natural mineral springs which have always enjoyed a high reputation in the cure of diseases of the skin, owe it almost, if not entirely, to the properties of the water alone. The various mineral ingredients are contained in too small quantities to exercise the effect they are usually found to produce, and until far more accurate observations shall have been made than are at present on record, a well-founded scepticism as to the mode of action of mineral springs must continue to exist, although it cannot be denied that certain skin diseases are at times benefited by recourse to the various health resorts where such springs are found. *Arthur Van Harlingen.*

BATTEY'S OPERATION (Normal Ovariotomy; Spaying; *Castration der Frauen*). The removal of the ovaries, apparently normal or somewhat enlarged, cystic or not, in normal position or prolapsed, painful in varying degree, sometimes acutely so, for the relief of such continuous local pain, or intolerable dysmenorrhœa, or for reflex pain and other neurotic disorders, as insanity and epilepsy, clearly associated with these organs. In 1823 Dr. James Blundell,[1] in a paper read before the Royal Medico-Chirurgical Society of London, stated his belief that the ovaries could be removed with safety, that in his opinion it could scarcely ever be justifiable, but that it would be the most effectual remedy for obstinate dysmenorrhœa, and in bleeding from monthly determination to the inverted uterus when extirpation was rejected. Dr. Blundell never carried his idea into practice. In July and August, 1872, within a few weeks of each other, each without any knowledge of the other's work, Professor Hegar, of Freiburg, Mr. Lawson Tait, of Birmingham, Eng., and Dr. Robert Battey, of Rome, Ga., U. S., performed the operation in the order mentioned. Dr. Battey alone at this time published a report of his case, which was successful, in the *Atlanta Medical and Surgical Journal.*

An epoch of development had been attained; the time was ripe. To Dr. Battey is undoubtedly due the credit of demonstrating to the profession the practicability and value of an operation now all but universally admitted to an honored place in surgery. Dr. Battey, in speaking of the operation known by his name, says: "This operation is peculiar in that it has for its primary object, not the removal from the body of a diseased organ, but the abrogation of a physiological function. While it is undoubtedly true that the ovaries extirpated in the majority of instances are structurally diseased, the end aimed at is not the removal of diseased though functionally active ovaries, but it is the production of the change of life by art." He early foresaw that the sphere of applicability of the operation in exceptional cases must be as widely extended as the very diverse effects of the vascular and nervous perturbations which follow upon perversions of the function of ovulation and of menstruation, which depends upon it. He proposed the operation as a *dernier ressort* only. "Ovariotomy to determine the change of life, and the change of life for any grave disease which is incurable without it, and curable with it." As an assistance to the operator in deciding the question of its propriety, he should ask himself the following questions:

Is this a grave case? Is it incurable by any of the resources of art short of the change of life? Is it curable by the change of life? If all three of these questions can be answered affirmatively the case is a proper one, but if not the operation is not to be justified.

The operation then is indicated:

1. In cases of absence of the uterus, or obliteration of

its cavity, or irremediable absence or obliteration of the vaginal canal, in which life is in danger or health destroyed by reason of the deficiency. In such cases it is the only promising and permanent means of relief.

2. In cases of insanity or confirmed epilepsy, dependent upon uterine and ovarian disease, it is justifiable as a last resort and when other means of cure have failed.

3. In cases of long-protracted physical and mental suffering, dependent upon monthly nervous and vascular perturbation, which have resisted persistently all other means of cure, the question of a resort to the operation is to be committed to the prudent judgment of the conscientious practitioner in each particular case.

In these propositions Dr. Battey included all cases to which he thought the operation applicable.

4. In cases of myoma of the uterus attended with exhausting hæmorrhages, in which the tumor cannot be safely enucleated, or the uterus with its tumors extirpated with reasonable safety; in such the removal of the ovaries, with consequent menopause, arrest of hæmorrhage, and atrophy of the tumor, is a valuable resource.

To Professor Trenholme, of Montreal, is due the credit of having first carried out the operation with this specific purpose. His first operation was done on January 13, 1876. He was speedily followed by Professor Hegar, of Germany, by Mr. Lawson Tait, of England, and subsequently by others.

In the cases included in the first proposition, there can be no doubt of the propriety of removing organs by whose influence the symptoms are produced.

In the second class, if the premises be clearly proved, that the insanity or epilepsy are due to uterine or ovarian disease, the conclusion of the justifiability of the operation must be accepted; but here difficulties will often be encountered. In each case the evidence will require the most careful sifting and weighing to enable the conscientious practitioner to arrive at a just decision. The reflection that grave conditions justify heroic procedures will much assist him in forming it.

In the third class, however, will be found the largest number of cases opposing difficulties in the way of arriving at a decision. The inquiry must be directed mainly in two lines: First, the intensity or gravity of the pain or other disturbance, and its effect on the system generally. It is a fact within the experience of every observer that pain is a relative symptom, and that many women are wont to describe their sufferings in extravagant language, abounding with superlatives. On careful inquiry from those who have the patient constantly under observation, it will often be found that she is capable of a good deal of interest in and enjoyment of life, and that nutrition is fairly maintained. These are cases in which, as Dr. Emmet says, "a little moral suasion, administered with firmness, accomplishes a great deal, and nature will often, when aided, bring about a favorable change in nutrition when least expected."[2] An important element in many such cases is the effect of opium, to which the sufferer is addicted. This is greatly to intensify the pain when the immediate effect of the dose has passed away. The actual pain cannot be correctly estimated till the patient is cured of her morphia-habit. The results, in such cases, of treatment mainly neuropathic and nutritive, such as that devised by Dr. Weir Mitchell, have been so remarkable as to leave no room for doubt that by it might have been cured some of those who have been subjected to this dangerous operation. Such treatment, however, is within the reach of but few. For those who cannot obtain it the risk of the operation may be justifiable, although experience has demonstrated that in many it is but an important step toward recovery.

The second line of inquiry must be to determine the actual seat and nature of the pain. Is it truly in the ovary? and if so, is it truly neuralgic, or due to anatomical changes in the organ? If neuralgic, is it essential in the ovary, or is it reflected from uterine or other disease? In the latter case, the prospects of cure by removal of the ovary would not be good. The testicle has been removed for neuralgia without curing the pain. Removal of the ovary would not be any more certainly successful in curing neuralgia of that organ. Such has been the experience in a few of the reported cases. In the light of increased experience the fourth class of cases appears to furnish the most promising field for this operation. Authorities of equal eminence are not, however, unanimous in advising it in preference to enucleation or hysterectomy. It has, however, been demonstrated to a certainty that, after the removal of the ovaries for bleeding myoma, in the very large majority of cases menstrual hæmorrhages cease, and the tumor atrophies and ceases to give trouble, or, in a small proportion, completely disappears. These results are much more certainly attained in small and medium-sized tumors than in large ones. They are so uncertain in tumors large enough to distend the abdomen that, by some, the operation is discarded for them *in toto*. For suitable cases of myoma we have, therefore, in this operation, a most valuable resource. So impressed is Mr. Lawson Tait with the dangers of enucleation of submucous myomas, and so successful has he been with removal of the uterine appendages, that he has completely discontinued the former operation. He now invariably removes the Fallopian tubes as well as the ovaries, believing that thereby he more certainly arrests menstrual discharge, which he believes to be due to an influence derived from the tubes rather than the ovaries. This theory cannot yet be accepted as proven, but in the present state of the question it is better to remove both. If the operation is called for at all, both ovaries, and not one only, must be removed, as success depends on the arrest of ovulation.

Dangers of the Operation.—The mortality, as given by different operators, varies so much that it is difficult to indicate it with any precision. There can be little doubt that if all cases were published it would be relatively high—probably more so than in ordinary ovariotomy. In the hands of Mr. Lawson Tait and his colleague at the Birmingham Hospital for Women, Dr. Thomas Savage, of Professor Hegar, and others of large experience, it is low. Of forty-five cases of removal of the appendages (tubes and ovaries) for myoma by Mr. Tait, reported in the last edition of his work on "Diseases of the Ovaries" (fourth edition, 1883), he lost but two. The mortality may, in general, be said to vary from five to twenty-five per cent.

Modes of Operation.—These have been two: vaginal and abdominal. Dr. Battey's earlier operations were, with one exception, done by the vaginal method. In the case of entire absence of adhesions and prolapse of the ovaries in Douglas' pouch, this method is, perhaps, the easier and safer. But the question of adhesions is one very difficult to positively settle before the operation. The possibility, in a given case, of being obliged to abandon an incomplete vaginal operation and of leaving it so, or of completing it by abdominal section will always militate against the selection of this method, except in the most favorable cases.

Vaginal Operation.—After thorough antiseptic douching of the vagina and etherization the patient is laid on a table in Sims' position, and a Sims speculum of suitable size, and short, slightly cupped blade introduced. The uterus is drawn down by a volsella fixed in the cervix, and held by an assistant. The posterior cul-de-sac is now incised with scissors to the extent of an inch and a half, in the middle line, beginning close to the uterus. The index finger is then introduced, and by it, or a long-handled polypus forceps, the ovaries are successively brought down through the wound, while an assistant presses on the hypogastrium. The pedicle is transfixed by a double ligature, and, after interlocking of the ligatures, tied on either side, or secured by Tait's Staffordshire knot, to be described later. The ovaries are then cut off with scissors, and, after watching for bleeding, the pedicle is returned. In most of Battey's operations a ligature was thrown around the base of each ovary, and the organs were then slowly removed by the *écraseur*. He then removed the ligature. The wound may be sutured or not. A drainage-tube has occasionally been used. The vagina may be tamponed by iodoform gauze or sublimate jute for a few days, with antiseptic injections in the intervals.

Abdominal Method.—This is the one which is now almost universally employed. It is often a more difficult operation than ordinary ovariotomy. It is especially so because of the greater rigidity and thickness of the abdominal walls than when they have been previously distended by a tumor. The same preparation and after-treatment of the patient are necessary as for ovariotomy. The same instruments and appliances, except cyst forceps and trocar, are necessary. The preliminary incisions are similarly made (see article Ovariotomy). On reaching the peritoneum it must be opened with great care, lest some coil of intestine, or the omentum, which immediately underlie it, shall be wounded. These parts are also much more apt to suffer injury from the manipulations necessary to separate adhesions and apply ligatures, or to stay bleeding by cautery or ligature. After the peritoneal cavity is opened, the left index and middle fingers are introduced, and made to feel the fundus of the uterus. This serves as a guide to the ovaries and tubes, which, having been found, are grasped between the two fingers and raised to the surface. In this the operator may be greatly aided by the use of Marion Sims' repositor in the uterus, or by two fingers or the whole hand of an assistant in the vagina, raising all in front of the posterior vaginal wall. The broad ligament is transfixed at a point clear of vessels, by a round needle threaded so as to form a loop. For this purpose both ends of the thread are passed through the eye in the same direction. This is made to draw through a loop of thin carbolized Chinese silk. The loop of silk is then cut, and the two ligatures thus formed are made to interlock and are tied on either side; that next the uterus is applied over the Fallopian tube as close as possible to the cornu of the uterus, and the other is passed beyond the fimbriated extremity. The distal part thus ligatured includes the ovary and whole Fallopian tube, or the Staffordshire knot of Mr. Lawson Tait may be used. In this the silk ligature is passed by transfixion, as already described, but the loop of silk is left entire. This loop is turned back over the ovary and tube till it lies at the point where the two free ends lie. One of these is brought above it, so that the loop lies between the free ends—one above and the other below it. The fingers and thumb of the left hand now holding the ovary and tube, the two ends of the ligature are grasped by the right hand, drawn up, and securely tied. The effect of this knot is to gather the pedicle while it secures it. The following illustration by Dr. Emmet[3] assists very much in understanding the description: "Let the reader lay a loop of cord between the index and adjoining finger, then turn the loop back over the tips of the fingers, pass one of the loose ends under the loop, draw tight and tie." The ovary and tube being now cut off with scissors, the stump is grasped with artery forceps, and watched a minute or so for bleeding. If secure, the ligatures are cut short, and the pedicle dropped. All the rest is the same as after ordinary ovariotomy.

In the most satisfactory cases the recovery from the operation and the previous symptoms is prompt. In cases with much neurotic complication it may be gradual, requiring the assistance of suitable neurotic treatment. The inflammatory exudations which sometimes form about the site of the ligatures or elsewhere in the pelvis, may act as sources of local or reflex irritation, perpetuating for a time the symptoms and requiring time for their removal.

Physiological Effects.—The arrest of menstruation is almost invariable when every particle of ovarian stroma has been removed. In this connection the possible existence of supernumerary ovaries must be remembered. Other cases of persistence are to be explained by the effects of long-existing habit of system. The patients often experience the sensations attendant on natural menopause, especially the vascular and nervous disturbances, flushings, etc. Sterility is, of course, a certain result, but the patients are in almost all cases sterile from the disease which rendered the operation necessary. Sexual feeling and appetite are in nowise impaired. The womanly graces are not at all lost or impaired. On the contrary, with removal of suffering and improvement of nutrition they become more pronounced. Theoretical speculations about the development of masculine characteristics, in which some have indulged, are as groundless as they are absurd.

See Dr. Battey's papers, Trans. Am. Gyn. Soc., vols. i. and ii.; Dis. of Ovaries, by Lawson Tait, 4th ed., 1883; Trans. International Med. Congress, 1881 and 1884. At this latter meeting, held at Copenhagen, Professor Hegar read a paper on "Castration for Neuroses," which, with discussion by Koeberle, Sir Spencer Wells, Martineau, Olshausen, Gunerow, Kugelmann, Priestley, Engelmann, and Gordon, is by far the most important recent contribution to the literature of the subject. Also a paper at same meeting, by Wiedow, on "Castration for Uterine Myoma," *Centralblatt für Gyn.*, Nos. 36 and 37, 1884.

William Gardner.

[1] Aveling: The Spaying of Women. Obst. Jour. Great Britain and Ireland, vol. vi., p. 617.
[2] Gynæcology, page 660, third edition, 1884.
[3] Principles and Practice of Gynæcology, third edition, 1884.

BAY, OIL OF (*Oleum Myrciæ*, U. S. Ph.). An essential oil obtained from the leaves and berries of *Myrcia acris* D. C.; *Pimenta acris* Wight. Order, *Myrtaceæ*.

This West Indian tree is not to be confounded with the European Bay, *Laurus nobilis* L.; although the leaves and qualities are very similar, the plants are entirely different. *Myrcia acris* is a fine, fragrant evergreen, with large, stiff, oval or obovate entire leaves, and clusters of sweet-scented white flowers. In general structure, the flowers and fruit resemble those of the allspice tree, to which it is closely related.

The oil is usually distilled in the West Indies, and imported into the United States in bottles; a considerable part of that used here is said to be smuggled by sailors into various Southern ports. A few years ago, Mr. Geo. F. H. Markoe, of Boston, imported a quantity of the leaves, and subjected them to distillation. His example has been, to a slight extent, followed. The oil so obtained from dried leaves, is not quite so bright and fragrant as the best imported, but is much better than the common grades. Oil of bay is thus described in the Pharmacopœia: "It is a brownish or dark brown liquid, of an aromatic, somewhat clove-like odor, a pungent, spicy taste, and a slightly acid reaction. Specific gravity about 1.040. Soluble in an equal weight of alcohol." According to Markoe, it is a mixture of light hydrocarbons with a heavy oil, probably *eugenol* (see Cloves).

Its medicinal qualities are those of the stimulating oils in general (allspice, cajuput, cloves, etc.), but it is only employed as a grateful perfume. Bay rum, which is the form in which it is generally used, was originally made by distilling rum from the fresh leaves and branches. But this imported perfume is now generally substituted by a simple solution of the oil in Cologne spirit or alcohol, flavored or not according to the taste of the manufacturer. As it is considerably used about the sick, a formula is furnished by the Pharmacopœia, as follows: "Spiritus Myrciæ, Oil of Myrcia, 16 parts; Oil of Orange Peel, 1 part; Oil of Pimento, 1 part; Alcohol, 1,000 parts; Water, 782 parts. Dissolve and filter. It is better when kept some time."

Allied Plants.—The genus *Myrcia* is a very large one, containing about a hundred species of tropical American shrubs or trees, having in general similar qualities The nearest other medical genera are, *Pimenta* (Allspice), and *Caryophyllus* (Cloves), to which the reader is referred.

Allied Drugs. — Those above referred to, and perfumes and spices in general. There is another officinal perfume, viz., Cologne Water (*Spiritus Odoratus*, U. S. Ph.).

W. P. Bolles.

BDELLIUM (*Bdellium d'Afrique*, Codex Med.). The Bdelliums, for there are two varieties, are gum resins of the frankincense type, from two at least, probably several species of *Balsamea*. The East Indian Bdellium is reputed to come from *Balsamea* (*Balsamodendron*) *Mukul* Engl.; that of Africa from *B. africana* Engl. Order

Burseraceæ. The latter is the variety officinal in France; neither is so in any other country.

Bdellium resembles myrrh in appearance and qualities. It is in small yellowish or reddish-brown tears, or sometimes in larger masses; transparent, fragrant, brittle. It softens between the teeth, and crackles in the flame. The odor and taste resemble those of myrrh, but are weaker. It contains about sixty per cent. of *resin,* between thirty and forty of *gums,* mostly bassorin, and one or two of *volatile oil.*

Bdellium is a mild local stimulant like myrrh, of which it is almost an exact duplicate; and is now and then used in Europe in plasters.

ALLIED PLANTS AND DRUGS.—See MYRRH.

W. P. Bolles.

BEARBERRY (*Uva Ursi,* U. S. Ph.; *Uvæ Ursi Folia,* Br. Ph.; *Folia Uvæ Ursi,* Ph. G.; *Uva Ursi, Raisin d'Ours, Busserole,* Codex Med.) *Arctostaphylos Uva Ursi* Spreng. (*Arbutus Uva Ursi* Linn.); Order, *Ericaceæ.*

This little gregarious, evergreen shrub, with reclining or creeping stems, and stiff, shining, green leaves, is at home on the dry hills and plains in the colder parts of the entire north temperate zone. It has the habit and appearance of the cranberry vine, but is much more leafy and robust. Botanically it differs from the other in having a free ovary. The flowers are in small clusters at the ends of the branches. They are globose or ovate, about five or six millimetres long (one-fourth inch), with short, recurved, pinkish lobes. There are ten stamens, and a five-celled, five-seeded ovary. Fruit, a little drupe.

The leaves, which are the part used, are nearly sessile, about two centimetres (four-fifths inch) in length; narrowly obovate or spatulate, with entire, slightly revolute margins They are dark green and shining above, pale green beneath. The dried leaves preserve their color well; they have a faint, herby, or tea-like smell, and a not unpleasant bitterish-astringent taste.

Uva Ursi contains both *tannic* and *gallic acids*—the former in large quantity; also *ericolin,* to which part of its bitterness is due. This is an amorphous, yellowish glucoside, yielding with diluted acids sugar, and an essential oil—*ursone;* another constituent appears to be a sort of stearoptene; it is in tasteless crystals. But the most important substance yielded by the plant is the crystalline glucoside *arbutin,* which it contains in common with a number of other *Ericaceæ.* It is obtained by condensing a decoction of the leaves (after this decoction has been freed from gallic acid), when the Arbutin crystallizes out, and may be purified by the usual methods. It is a bitter, hygroscopic, neutral substance, in silky, needle-shape crystals, dissolving with difficulty in cold water, but easily in hot water or alcohol. By digesting it with emulsin or diluted sulphuric acid, sugar and *hydrochinone* are produced.

USE.—Of definite physiological action there is not much to be predicated for *Uva Ursi,* excepting astringency. This the large amount of tannic matters (more than one-third) easily explains. That the different bitter principles make it, to a slight extent, tonic, there is no doubt. Its influence upon the kidneys and urinary passages, from a physiological standpoint, is not clear. Yet there is reason to believe that whatever value it has in this respect is due to the arbutin which it contains. This substance is eliminated by the kidneys partly unchanged, but mostly decomposed into hydrochinone, etc. This is a substance of some antiseptic power, and the suggestion is plausibly made that its value in chronic cystitis depends upon its antisepsis. On the other hand, pure arbutin, which should be far better in this view than Uva Ursi itself, has not proved especially valuable in the few cases in which it has been tried. The clinical evidence, both popular and professional, in favor of Uva Ursi is considerable, and to the effect that decided relief from pain and frequency of micturition, with sometimes diminution of pus in the urine, follows its use. A number of other drugs containing arbutin have been empirically put to the same use as this one, before the presence of the glucoside in them was demonstrated.

Dose of Uva Ursi, from two to four grammes (ʒ ss. ad ʒ j.), or more if the digestive organs are not disturbed by it. There is a fluid extract (*Extractum Uvæ Ursi Fluidum,* U. S. Ph.), strength, $\frac{1}{1}$, but decoction is probably a better form of administration. Arbutin is, so far, too expensive to use, but if much called for it ought to become comparatively cheap. Dose, perhaps, one gramme.

ALLIED PLANTS.—Uva Ursi, medicinally, fairly represents the order *Ericaceæ.* Arbutin is the most characteristic constituent found in it, and exists in a number of its genera. A few plants in it have a slender reputation as medicines. A few of its berries (especially if the *Vacciniæ* are included, *i.e.,* blue-, whortle-, huckle-, cranberries, etc.) are edible; many of its flowers—heaths, rhododendrons, kalmias, etc., are beautiful.

Arctostaphylos glauca, an American species, with larger roundish leaves, has similar qualities, and also contains *arbutin.* The following, and other genera, have furnished plants used in medicine: *Arbutus, Gaultheria, Epigea, Erica, Pyrola, Chimaphilla,* etc.

ALLIED DRUGS.—Benzoic acid and its salts are used with the idea of making the alkaline urine of vesical catarrh antiseptic, and so may be compared to arbutin. For a list of simple soothing diuretics, see COUCH GRASS.

W. P. Bolles.

BECCABUNGA (Codex Med.), the fresh herb of *Veronica Beccabunga* Linn.; Order, *Scrophulariaceæ.* This is a rather fleshy plant, with straggling, hollow stems rooting at the joints, and opposite leaves. These latter are ovate, finely serrate, or nearly entire. The flowers are in axillary racemes, small and blue, normally pentamerous, but asymmetrical by abortion, and irregular, the upper calyx-lobe, the lower division of the corolla, and three of the stamens being usually wanting. Ovary, two-celled, many-seeded. Beccabunga is a native of Europe, common along brook-sides and in swamps.

It has a sweetish, bitter, slightly warming taste, and contains a little essential oil, said to resemble those of the *cruciferæ,* besides some other ill-defined bitter substances.

Beccabunga is obsolete as a medicine. It has been used as antiscorbutic and diuretic, but has little value. Our salads in general—cresses, celery, dandelion, etc.—are probably just as good antiscorbutics, and have the advantage of being taken willingly. With lemons or lime-juice it is not to be compared. A syrup made from the fresh juice has been a favorite preparation.

ALLIED PLANTS.—The genus *Veronica* is very widely distributed, and comprises nearly two hundred species, in all parts of the world. They are in general bitter and not very active plants, with qualities usually described as "stomachic, diaphoretic, diuretic, and expectorant," a combination difficult to use in rational medicine. *V. officinalis* Linn., *V. Teucrium* Linn., *V. serphillifolia,* etc., will serve as examples. *V. virginica* (Leptandra) is, however, more active (see CULVER'S ROOT). For a notice of the order, see FOXGLOVE. *W. P. Bolles.*

BEDFORD ALUM SPRINGS, PENNSYLVANIA. *Location and Post-Office,* Bedford Springs, Bedford County, Pa., on the Bedford Division of the Pennsylvania Railroad. It is also connected with the Pennsylvania Railroad by a branch from Huntington, with the Baltimore & Ohio Railroad by a branch from Cumberland, Md., and with the Connellsville Division of the Baltimore & Ohio Railroad at Bridgeport. First discovered in 1804.

THERAPEUTIC PROPERTIES.—This water is analogous to the Alleghany and Blue Ridge Springs, though not so strong in the active ingredients, lime and magnesium sulphate, as either of them. It is useful as an alkaline cathartic, tonic, and diuretic, and has been long the favorite resort of the people of Pennsylvania and neighboring States.

The hotel accommodations are upon a large scale, and the opportunities for recreative exercise are many. The site is 1,080 feet above the sea, on the eastern slope of the Alleghany Mountains, and for beautiful scenery, pure air, and salubrity of climate, is all that can be desired. The "Sweet Spring" furnishes the ordinary drinking

water, and, according to Dr. Genth, is one of the purest of natural waters. There are good schools in the neighboring town of Bedford.

There are five springs: "Mineral," Sulphur, Chalybeate, Limestone, and Sweet.

The "Mineral," or Anderson Spring, is the chief one, and has, according to Dr. F. A. Genth, the following composition:

ANALYSIS.—Temperature, 58° F.; specific gravity, 1.029. One gallon of 231 cubic inches contains:

Carbonate of calcium	8.47132 grains.
Carbonate of magnesium	0.59120 "
Carbonate of iron	0.04659 "
Carbonate of manganese	trace.
Sulphate of strontium	0.00725 "
Sulphate of calcium	90.45513 "
Sulphate of magnesium	38.68368 "
Sulphate of sodium	0.60824 "
Sulphate of potassium	0.29582 "
Chloride of lithium	faint trace.
Chloride of sodium	0.53476 "
Phosphate of calcium	0.02248 "
Sulphide of hydrogen	0.00596 "
Silicic acid	0.16943 "
Carbonic acid (free)	1.27347 "
	140.56533 "

George B. Fowler.

BEDFORD ALUM SPRINGS, VIRGINIA. *Location,* Bedford County, Va.; *Post-Office,* New London, Campbell County, Va.

ACCESS.—By Norfolk & Western Railroad to Forest; thence by stage to the Springs, about five miles distant, near New London, in the adjoining county.

ANALYSIS (Professor William Gilliam).—One pint contains:

Sulphate of potassa	1.270 grains.
Sulphate of magnesia	1.583 "
Sulphate of lime	2.334 "
Sulphate of alumina	0.905 "
Sulphate of protoxide of iron	2.932 "
Sulphuric acid (free)	2.497 "
	11.521 "

THERAPEUTIC PROPERTIES.—This is a chalybeate-alum water of old repute, and is much frequented for the cure of diseases of the skin and mucous membranes.

This spring is situated in the Blue Ridge Mountain region of Virginia, and is about twenty-five miles from the "Peaks of Otter," 5,300 feet above the sea. *G. B. F.*

BEDFORD SPRINGS, KENTUCKY. *Location,* Trimble County, Ky.; *Post-Office,* Bedford, Trimble County, Ky.

ACCESS.—By Louisville & Nashville Railroad, Louisville, Cincinnati & Lexington Division, to Campbellsburg, eight miles; thence by stage to the Springs; or by Jefferson, Madison & Indianapolis Railroad, Madison Division, to Madison, Ind.; thence by turnpike, ten miles, to Springs.

ANALYSIS (Dr. Robert Peters).—Chloride of sodium, bicarbonate of magnesia, bicarbonate of lime, sulphate of sodium, carbonate of lithium, carbonate of soda. Reaction, alkaline to test-paper.

There are two springs, "The Bedford" and "The Epsom." They are of similar chemical composition, except that there is a larger proportion of sulphate of magnesia in the Epsom water.

The Bedford saline water issues from a hydraulic layer of four or five feet between strata of blue limestone, and is collected in a basin of the same material.

The Epsom water flows from calcareous clay, formed by the disintegration of the earthy beds overlying the limestone.

The Bedford water contains no carbonic gas, has no odor, is clear, pure, and pleasant to the taste. The ordinary drinking-water of the place is a clear, cool, freestone water.

THERAPEUTIC PROPERTIES.—The Bedford waters are extremely popular among the physicians and people of the South and Southwest. They are resorted to for the cure of catarrhal diseases of the alimentary canal and urinary organs, and are useful in rheumatism and gout. The climate is healthful, having an average summer temperature of 75° F. There are pleasant walks and drives through the neighboring country. Churches of various sects and schools are found at Bedford and Campbellsburg. The Bedford Springs Hotel, lately refitted and furnished, has accommodations for one hundred and seventy-five guests.

HISTORY.—The springs were discovered by Noah Parker in 1837, and have remained in possession of the family. In 1838 they were opened to the public, and have ever since retained their reputation.

George B. Fowler.

BELLADONNA (*Belladonnæ Folia, Belladonnæ Radix,* U. S. Ph., B. Ph.; *Folia Belladonnæ,* Ph. G.; *Beladone,* Codex Med., root, leaves, seed). *Atropa Belladonna* Linn.; Order, *Solanaceæ,* is a rather unsightly and heavy, disagreeable-smelling, perennial herb (from sixty to one hundred and twenty centimetres—two to four feet—in height), with an upright stem, terminating in three spreading and forked branches. The stem is smooth, the branches, when young, glandular, hairy. The leaves are normally alternate, but by the alternate suppression of internodes, those in the upper portions of the plant are approximated in ill-matched pairs, consisting of one large and one small leaf, arising near each other, not opposite. They are ovate or oblong, pointed at the apex, and tapering below into a short petiole; they are entire, smooth, and thin. The larger leaves are from fifteen to twenty centimetres (six to eight inches) in length, the smaller not more than half as large. The flowers are technically terminal, but apparently lateral, on recurved peduncles, solitary, of a dull brown-purple color, and are about two and a half centimetres long. Calyx five-parted, bell-shaped, in fruit large and open; corolla tubular bell-shaped, with a five-notched apex imbricated in the bud. Stamens, five; ovary free, two-celled, many-ovuled. Fruit a spheroidal, black, shining, many-seeded berry, from one and a half to two centimetres in diameter. Seeds small (one-third centimetre long, = one-eighth inch), flattened, kidney-shaped, light-colored, scrobiculate. Root thick and fleshy, light-colored.

FIG. 400.—Belladonna. Flowering branch (Baillon.)

Belladonna is a native of Central and Southern Europe and Western Asia. It is considerably cultivated for medicinal use in Europe, and occasionally in the United States, where it has also become sparsely naturalized; nearly all that used here, however, is imported from Europe. The wild plants are said to be the most active.

Belladonna, although a European plant, is not of great antiquity as a medicine; at least it cannot be recognized among those described by the oldest writers on this subject. From the beginning of the fifteenth century down, however, it is frequently referred to as a poison, and sometimes as a medicine. For the past hundred years it has been pretty regularly mentioned, and more or less used, but never very commonly until its usefulness in examinations and treatment of the eye opened for it a new and important field. It has been a panacea among the homœopathists from the foundation of their school.

DESCRIPTION.—The seeds are not much employed, and are sufficiently described above. The leaves have the form and size given above, and are, when dried, thin and brittle, brownish green above, grayish green below, with fine punctations indicating oxalate of calcium concretions; the younger leaves are finely hairy, the older smooth. They have a weak odor and a bitter disagreeable taste. Belladonna leaves should be collected in the summer, at the height of vegetation, and carefully dried in the shade; they become worthless by long keeping. The dried root is from three to five centimetres (1–2 inches) or more in diameter, and up to twenty or thirty centimetres in length, tapering, curved, occasionally branched, with a light-yellowish or grayish-brown and longitudinally wrinkled surface. It is usually split to facilitate drying, and is then in strongly recurved pieces. Within, its color is yellowish white. The woody ring is narrow, its cells thin-walled, its vessels large. The bark and pith of the main root are thick and starch-laden; the branches have no pith; the whole structure is light and not fibrous, and the fracture short and transverse. The broken surface is mealy with the abundance of starch. The taste is slowly bitter, and strongly acrid. The best roots are from young adult plants. Those which are six or seven years old, especially hollow, woody, tough, and decayed pieces, should be rejected. It should be collected in spring or fall.


FIG. 401.—Belladonna. Fruit; about two-thirds of the natural size. (Baillon.)

COMPOSITION. — The principal constituent, *atropine* (*Atropina*, U. S. Ph.), was discovered in 1833, simultaneously and independently, by Mein in the root, and by Geiger and Hesse in the herb, of belladonna. A number of methods for separating it are in use, all of them somewhat complicated. The following outline, essentially that of Proctor, will serve as an example. An alcoholic tincture is made from the root, and subjected to a first purification by treatment with slaked lime. Then it is neutralized with diluted sulphuric acid, by which means the lime is precipitated, and a sulphate formed with the atropine. The solution is then filtered and evaporated to a syrupy consistence, diluted with water, and filtered through a wet filter to remove fats, etc. It is then shaken with chloroform, which completes the removal of these substances, without dissolving the atropine sulphate, which is insoluble in chloroform. The watery solution is decanted, and finally treated to a second portion of chloroform; the mixed liquids are made alkaline again by means of caustic potash, which decomposes the sulphate of atropine and thus liberates the alkaloid itself, which is soluble in chloroform and is removed by that agent from the water. The liquids are again separated, and the atropine-chloroform solution evaporated to dryness; the alkaloid is, at last, crystallized from absolute alcohol. It is a colorless, white, crystalline alkaloid, permanent in the air; soluble in six hundred parts of cold water, and in sixty of ether; in alcohol and chloroform freely so. It has a bitter and acrid taste, and no odor. Atropine forms crystalline salts. One of these, the sulphate (*Atropinæ Sulphas*, U. S. Ph.), is generally used instead of the pure alkaloid, in consequence of its free solubility in water ($\frac{1}{0.4}$). It is less soluble in alcohol ($\frac{1}{6.5}$), but sufficiently so for all pharmaceutical or medical purposes. By the action of hot, concentrated sulphuric acid, and also by other means, atropine is decomposed into a similar but less active alkaloid tropine, and tropic acid, and from these can be again synthetically prepared. With tropine, also, a series of interesting salts with various aromatic acids may be formed, one of which is of some practical use, namely, *Homatropine* or oxytolyltropine, a combination of tropine with amygdalic acid. The hydrobromate of homatropine is especially adapted to use as a simple mydriatic in cases in which the pupil is to be dilated simply for examination, since its effect passes by very much sooner than that of atropine. It is a permanent, but easily soluble salt. The next most imporant alkaloid is *hyoscyamine*, which is the characteristic constituent of Henbane or Hyoscyamus. Its action in general is the same as that of atropine, and as it exists in Belladonna only in minute quantity its description will be deferred until Henbane itself is considered. *Belladonnine* is a more doubtful constituent, and may be an impure mixture of the above. The percentage of atropine varies much, according to different observers, but may be stated as about one-half of one per cent. in both the dried leaves and root. Commercial atropine is a mixture of atropine and hyoscyamine. The leaves contain also *asparagin*.

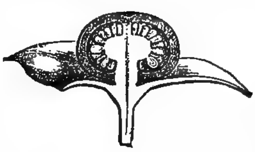


FIG. 402.—Section of the same.

The action of Belladonna is essentially that of its principal alkaloid; the other constituents are so small in quantity, or so inert in comparison, that they may be entirely ignored in this connection. Hyoscyamine even if present in appreciable amount, would scarcely modify its action, as the two alkaloids are nearly identical in medical properties.

The intense physiological activity of atropine has quite naturally made it a favorite subject of study with experimental physiologists, and its literature is rich and interesting, if not always harmonious. The following *résumé* covers only the most striking and practical points, and those most generally accepted. For further details, the reader is referred to works upon therapeutics. One of the first items of interest to be noted is the great difference which exists in the sensitiveness of different kinds of animals to its influence. To none is it so obnoxious as to man; to some it is scarcely deleterious. Herbivorous animals in general (horses, asses, etc.) can eat belladonna leaves in considerable quantity with impunity. Rabbits can be fed exclusively upon them for weeks, and until their very flesh is poisonous to man, without serious symptoms. They require a dose of atropine ten times as large as would be fatal to a man, to kill them. Many birds resist its action remarkably, and their pupils are not dilated by it. Young animals bear it in larger proportionate doses than adult ones; children than men. In general, animals whose nervous system is most highly developed suffer more from its action than lower forms. Atropine is easily introduced into the system by various channels; the lungs, stomach, rectum, vagina, and even the skin, are capable of absorbing it, and are all frequently made use of in its administration. Subcutaneously it acts as quickly as morphine given in the same way, and produces but little local inflammation. Upon the eyeball, it passes through the cornea in a few minutes in sufficient amount to make itself manifest. Finally, it is said to be capable of reabsorption from the bladder, into which it has been eliminated, a point to be borne in mind in cases of poisoning. Continued use of it begets a certain degree of toleration.

Atropine acts, in one way or another, upon all parts of the nervous system, as well as directly or indirectly upon the unstriped muscles and secreting organs. The name mydriatic (ἡμυδρίᾶσις), which is given to it and other solinaceous products in therapeutic classifications, refers only to one of a number of functional disturbances which it is capable of causing, and must not be taken as expressing its general, or even most important physiological, action. As a convenient basis of classification it has a certain use. In a word, it may be said to be an excitor of the nervous centres, and at the same time depressant to the nerves themselves and their peripheral connections; thus combining two kinds of action antagonistic in their nature, and causing divers series of symptoms, according to the relative intensity of its impression upon one or the other of the structures mentioned. The symptoms depend, in part, upon the animal experimented upon (in frogs, for instance, the paralyzing action is more intense; in mammals, the excitant), and in part upon the size of the dose. To repeat slightly more in detail, its exciting influence has been observed in the spinal column, where

it is shown by the development of convulsions; in the cerebrum, producing delirium; in the cardiac centres, affecting the action of the heart; in the respiratory centres, and in the sympathetic ganglia. On the other hand, it diminishes the conductibility of the nerves themselves, and so far disguises the impression which it has made upon the nerve-centres. The motor nerves feel its influence first and most fully, the sensitive fibres later. The vagus shares in the general paralysis of the efferent nerves, but the accelerator nerves of the heart, and the sympathetic nerves in general, are probably less paralyzed than those of the cerebro-spinal system. Finally, it reduces the irritability of the unstriped muscles (intestine, bladder, uterus, etc.), and diminishes the activity of the secreting glands in general (in the throat, skin, etc.). Its action upon the iris is of the greatest medical interest, in consequence of the practical value which it has for the oculist. This consists, after small doses, in a simple dilatation of the pupil; after larger ones, in paralysis of the power of accommodation as well. Both these effects may be produced by internal administration, and are, indeed, recognized as the first and most characteristic symptoms of poisoning by belladonna. They are essentially local in their character, however, and are better produced by the topical application of this medicine to the eye itself. When atropine, or its derivatives, are used in this way, its effects upon the eye may be graduated with the greatest nicety from a scarcely perceptible dilatation of the pupil to the most complete paralysis of the intra-ocular portions of the *motor oculi* nerve. Its action here corresponds in character with the action as manifested upon the rest of the nervous system. In man, a characteristic bright-red flush often makes its appearance after large, and occasionally after very small, medicinal doses. The writer has seen it more frequently in children than in adults. It always appears upon the cheeks, and may spread to other parts of the body; it is a smooth, bright, well-defined erythema, passing off in a few hours, usually without desquamation or any disorder of sensation; it often encircles the mouth, enclosing a white area around the lips, which is quite characteristic. Dizziness, confusion of thought, hallucinations, and mild or wild delirium, indicate different degrees of stimulating action upon the cerebrum. The bodily temperature is raised by full medical doses. The excessive dryness of the throat, which is one of the most distressing symptoms of atropine poisoning, is due to the cessation of secretion there.

With the above *résumé* of its action the medicinal uses of belladonna will appear rational. Some of its effects, such as the spinal irritant (convulsions) and the cerebral stimulant in high degree (delirium), are not brought out in medicinal doses; and others, while often present, like the dryness of the throat, are disadvantageous, or only useful as a gauge of the amount of impression produced. 1. As an antispasmodic it has been used with benefit in a number of diseases, when the relaxation of spasm or diminishing the irritability of nerves and muscles is desired. Such conditions are found in asthma, whooping-cough, colics, dysmenorrhœa, rigidity of the os uteri in labor, vaginismus, infantile incontinence of urine, etc. In all these diseases belladonna has been of undoubted benefit. Often, it must be confessed, it has failed more or less completely. In epilepsy, for which it has been largely used, it has probably but little value. In chronic constipation it is often very useful, not as a cathartic itself, but as a corrigent to some active laxative. For its sedative effect the more locally belladonna can be applied the more efficient it will prove; thus in asthma it is best inhaled (smoke, spray); for uterine and rectal cases, given as an ointment or suppository; in neuralgia, injected into the painful part, etc. By this means greater excess of local over central effect is produced. 2. As a stimulant to the circulation and respiration (for these results both appear and are usually both wanted together) large doses are required, and the conditions are not often present when, with all its drawbacks (choking, thirst, mydriasis, etc.), it is desirable; but when they are present, as in excessive collapse, with failing pulse and respiration, with reduction of temperature and cold perspiration, life is in danger, and atropine may be the means of saving it. There is no other medicine which so completely antagonizes these symptoms as this. Such collapse may occur in the course of disease as a result of accident, or in poisoning by opium. The writer believes that he has seen two cases in which atropine used in this way was the means of saving life. One was a case of typhoid fever, complicated by lobar pneumonia, in which the patient had a sudden collapse; the pulse had fallen to between forty and fifty, and could hardly be felt; the respirations were not more than eight in a minute; he was covered with cold perspiration, was cyanotic, and could scarcely speak. Alcohol was not responded to. He was given a moderate dose of atropine sulphate, which brought the pulse and respiration perceptibly up in a few minutes, and after a repetition of the dose the perspiration diminished, and later disappeared; the temperature had been down to ninety-six, but rose after the atropine to nearly normal in an hour or two. The collapse returned after several hours, but was again overcome by the medicine. The second case was one of collapse after a secondary amputation of the thigh, in a patient who had lost much blood in successive hæmorrhages (he was a bleeder); the symptoms were similar to those above given, excepting that the temperature was not so much lowered. Both men were believed to be dying. In such cases it should be given subcutaneously.

Atropine is used in ophthalmic practice, both as a remedy and as a means of diagnosis: for the latter purpose, sometimes to dilate the pupil sufficiently for a full view of the interior of the eye, sometimes to paralyze the power of accommodation, and thus facilitate a careful examination of its refraction, etc. For these purposes the smallest doses, that is, the weakest solutions that will answer the required purpose, should be applied to the conjunctiva; a drop or two of a solution made with one or two parts of sulphate of atropine in ten thousand of water, will dilate the pupil sufficiently for an examination of the fundus, etc., without, it is said, having much effect upon the power of accommodation; to impress this function a solution of four or five parts in a thousand is required. The dilatation of the pupil begins in a few minutes after the application, the paralysis of accommodation after an hour or so. It requires from three to fifteen days, according to the amount of disturbance produced, for the functions to become normal again. The eye should therefore not be atropinized without good reason—a week or two of time is sometimes unnecessarily lost, for a patient who is in business, by an injudicious or not needed application, to make an examination easy, which, with a little more care or skill, could be well enough done without it.

Therapeutically it is employed in a number of diseases where rest, a soothing effect, and a reduction of intra-ocular pressure is desired; some forms of conjunctivitis, ulcerations of the cornea, *ophthalmia neonatorum*, spasmodic disorders of the accommodating power, and glaucoma, are examples. But its mydriatic power is the key-note to its greatest and every-day usefulness in ophthalmic therapy. In iritis it is of the highest importance to keep the inflamed iris still, relaxed, and free from friction and pressure, also to hold it where it shall not be in danger of forming inflammatory adhesions. Atropine does this to an ideal extent, and may be compared to a splint for a broken limb in its usefulness. The disease is shortened and greatly mitigated by its application. It is not, however, a specific, and should be accompanied with the anti-rheumatic or antisyphilitic treatment which the nature of the case further indicates.

Belladonna has been extensively used *empirically* for a great variety of diseases, as may be seen by consulting the older works upon medicine. None of these uses have stood the test of experience, excepting those which may be explained by its physiological actions. As a prophylactic in scarlet fever its action is probably merely a moral one. It certainly sometimes relieves the minds of those taking it, even when they are distinctly told that it has no value in this respect. The doses employed for this purpose are generally very small.

Administration.—Neither the root nor the leaves are

usually given in substance, although there appears to be no good reason for not doing so, as the dose is small, and they are certainly as uniform as the Galenical preparations made from them; the dose of the *leaves*, when given, is also stated to be larger than that of the root—which seems hardly logical, since the alkaloidal strength averages in each about the same. The leaves are, however, an uncertain and perishable drug, and might well be spared. Their maximum dose, according to the German Pharmacopœia, is two decigrammes (0.2 Gm. = gr. iij.), or not more than six decigrammes *per diem*; the real dose is a tentative one, to be increased until its effects are noticed.

PREPARATIONS.—From the leaves are made: an alcoholic extract (*Extractum Belladonnæ Alcoholicum*, U. S. Ph.), so named to distinguish it from the English extract made from the fresh leaves. The dose is uncertain; one and a half centigramme (one-fourth grain), introduced into the stomach or rectum, will sometimes affect the throat and pupils, and may be taken as an average to start from. The ointment (*Unguentum Belladonnæ*, U. S. Ph.), consisting of extract $\frac{1}{10}$, benzoinated lard and alcohol $\frac{9}{10}$, is much used as a sedative application to the rectum and uterus. The tincture (*Tinctura Belladonnæ*, U. S. Ph.), strength $\frac{15}{100}$, dose one to two grammes (1 to 2 Gm. = ♏xv. ad xxx.).

From the *root* are made; an abstract (*Abstractum Belladonnæ*, U. S. Ph.), strength $\frac{2}{1}$, a fluid extract (*Extractum Belladonnæ Fluidum*, U. S. Ph.), strength $\frac{1}{1}$, dose one or two decigrammes (0.1 to 0.2 Gm. = ♏jss. ad iij.), which is the most uniform preparation. The liniment (*Linimentum Belladonnæ*, U. S. Ph.) is the fluid extract with five per cent. of camphor. For the officinal plaster* (*Emplastrum Belladonnæ*, U. S. Ph.), an alcoholic extract is made from one hundred parts of the root, and then mixed with enough resin plaster to make the amount weigh one hundred parts.

Atropine and its sulphate (*Atropina*, *Atropinæ Sulphas*, U. S. Ph.), are both officinal, but the latter only is used for dispensing, on account of its solubility. It is a perfectly uniform and trustworthy preparation, and in the writer's opinion is always to be preferred for internal administration. Dose, one milligramme (0.001 Gm. = gr. $\frac{1}{60}$).

Homatropine acts like atropine upon the eye, but its effects are more transient, passing over in a day or two—a peculiarity that makes it very valuable for simple examinations. A solution containing four or five parts of, say the *Hydrobromate* of *Homatropine*, in a thousand of distilled water, is one of suitable strength. Solutions of both atropine and homatropine are apt to develop fungous growths, and to become injured by them; this may be prevented by adding one part in a thousand of thymol, or two in a thousand of carbolic acid, when they will keep indefinitely.

ALLIED PLANTS.—*Atropa Belladonna* is the principal medicinal plant of the order *Solanaceæ*, and the centre of a small group of poisonous plants of remarkably similar qualities; but, besides these, the order contains other members of the greatest economic value and interest, and supplies also some beautiful flowers.

The order is a large one, containing over twelve hundred species, generally inhabitants of warm latitudes, especially of South and Tropical America, but having a few representatives in the temperate portions of Europe and America. Its qualities are always suspicious, and sometimes intensely poisonous, yet a few most valuable articles of food are supplied by it. Its active principles are usually alkaloids, but there are some notable exceptions to this, like Capsicum. The following synopsis will serve to illustrate the variety and richness of the order:

1. *Lycopersicum esculentum* Dunal, the common Tomato. The leaves are said to contain *Solanine*.
2. *Solanum tuberosum* Linn., the Potato. Contains *Solanine* in its fruits, etc.
3. *Solanum nigrum* Linn., Deadly Nightshade. Contains *Solanine*.
4. *Solanum Dulcamara* Linn., Bittersweet. Contains *Solanine* and *Dulcamarine*.
5. *Solanum esculenta* Dunal, the Egg Plant.
6. *Physalis Alkekengi* Linn. Contains "*Physalin*."
7. *Capsicum annuum* Linn., } Red Peppers. Contain
8. *Capsicum fastigiatum* Bl., } a trace of *Solanine*, but owe their chief qualities to an intensely acrid substance called *Capsaicin*.
9. *Lycium* "*Matrimony*." Cultivated for ornament.
10. *Atropa Belladonna* Linn., *Atropine* and *Hyoscyamine*.
11. *Datura Stramonium* Linn., *Hyoscyamine* (Daturine), *Atropine*.
12. *Hyoscyamus niger* Linn., Henbane. *Hyoscyamine*, *Hyoscine*, *Atropine*.
13. *Nicotiana Tabacum* Linn., Tobacco. *Nicotine*.
14. *Petunia*, } ornamental plants.
15. *Nierembergia*, }
16. *Duboisia Myroporoides*, *Hyoscyamine* (Duboisine), etc.

ALLIED DRUGS.—Nos. 11, 12, and 16 in the above list have about the same properties as belladonna. Some of the others resemble it in certain points, but not so nearly. Besides these, there are no drugs having exactly such a combination of effects upon the animal system. It has, however, one or two remarkable antagonists in certain respects: *Physostigma* contracts the pupil as actively as the medicine under consideration dilates it, and is frequently used to overcome its action. The respiratory and cardiac stimulating powers of belladonna antagonize the paralysis of these organs in deep *opium* narcosis, and it occasionally proves serviceable in cases of poisoning by that drug. *W. P. Bolles.*

BELLADONNA, POISONING BY. The *atropa belladonna* is a member of the well-marked natural order Solanaceæ, which includes so many species having distinct physiological activity. Since the plant does not grow wild in this country, poisoning only occurs from the use of the medicinal preparations, but numerous cases are recorded by foreign observers in which different parts of the plant have caused fatal effects. Even the endermic application of belladonna has caused marked symptoms.

The symptoms produced by toxic doses of the preparations of belladonna usually manifest themselves within an hour, and are marked and characteristic. They are heat and dryness of the mouth and throat, increasing to a feeling of burning or constriction, difficulty of swallowing, giddiness, nausea and vomiting, frequently, but not invariably; great mental excitement, delirium, and hallucination, often decidedly maniacal or hysterical. The circulation is decidedly affected, the pulse being quickened, the face becoming red and turgid, and in some instances a scarlet eruption has appeared over the body. Dilatation of the pupil, with insensibility to light and impairment of vision are usual and important symptoms. The mental symptoms often take the form of wild and uncontrollable laughter. The following case, admitted into Guy's Hospital, detailed by Taylor ("Treatise on Poisons"), illustrates very well the clinical history of a case of belladonna poisoning. The patient, a boy, aged fourteen, had eaten soon after breakfast about thirty belladonna berries. In about three hours it appeared to him as if his face was swollen, his throat became hot and dry, vision impaired, objects appeared double, and seemed to revolve, and run backward. His hands and face were flushed and his eyelids swollen; and occasional flashes of light were experienced. He tried to eat, but could not swallow on account of the state of his throat. In endeavoring to walk home he staggered, and felt giddy whenever he attempted to raise his head. He was incoherent, frequently counted his money, and did not know the silver from the copper coin. His eyes had a fixed and brilliant look, he could neither hear nor speak plainly, and was very thirsty; he caught at imaginary objects in the air. There was

* The belladonna plaster so extensively found in the pharmacies of the United States, already made and spread, is not the officinal one, but is made with a basis of caoutchouc.

headache, but no vomiting nor purging. These symptoms were much the same nine hours after the taking of the poison. The pupils were so strongly dilated that there was merely a narrow ring of iris; the eyes were quite insensible to light, the eyelids did not close when the hand was passed suddenly over them, but the nerves of common sensation were unaffected. The pulse was ninety, feeble, and compressible. He continued in this state for two days, but gradually recovered.

Fatal cases usually terminate in coma, less frequently in convulsions.

The activity of belladonna is due principally to the alkaloid atropia (atropine), which is distributed throughout the plant; but the leaves and root, especially the latter, contain it most abundantly. According to Wormley ("Micro-chemistry of Poisons") the average amount present is not more than one-third of one per cent. In the pure state it is one of the most potent poisons known, the medicinal dose being limited to about the sixtieth of a grain, generally in the form of the sulphate. Cases of poisoning by the alkaloid are rare; they are, of course, similar in clinical history to that detailed above. There is a close resemblance between atropia and the so-called *daturia*—the alkaloid extracted from stramonium. Some authorities regard them as identical.

The treatment of belladonna (or atropia) poisoning is both direct and physiological. Free evacuation of the stomach by means of emetics, or the stomach-pump, should be resorted to; as antidotes, animal charcoal or tannic acid may be given. The former has been found efficacious by actual experiment on the human subject; it acts by absorbing the alkaloid · tannic acid renders it insoluble. Both these agents are, however, only temporary, they do not set aside the necessity for evacuating the stomach or using other remedies. Since physostigmia—the active principle of the Calabar bean—and also morphia cause contraction of the pupil, they have been naturally suggested as physiological antidotes to atropia, and clinical experience has borne out this view. The hypodermic use of these agents should therefore be cautiously employed, the condition of the pupil and the general nervous symptoms being used as guides to the medication.

A fair proportion of the recorded cases of belladonna poisoning have recovered under treatment. When a fatal result takes place, no special or characteristic post-mortem appearances are discoverable.

There are no striking or easily applied chemical tests for atropia. It may be identified by its physiological action, dilatation of the pupil. *Henry Leffmann.*

BENNÉ OIL (*Oleum Sesami*, U. S. Ph.), *Sesamum indicum* Linn.; Order, *Pedaliaceæ*, is an erect hairy annual, from sixty to one hundred and twenty centimetres (2 to 4 feet) in height, with various-shaped, ovate or lanceolate serrated leaves (the lower ones often three-lobed or cleft), and small, rose-colored, irregular flowers. The capsule is velvety, pointed, falsely four- (normally two-) celled, with numerous seeds. The latter are the source of the oil, of which they contain from sixty to seventy per cent.

The Benné plant is a native of Africa, and probably also of Asia, but is not found in an indubitably wild state, having been cultivated on both these continents from a remote period. It has been introduced further into all tropical countries, and is extensively produced for the sake of its seeds, which are used in various ways for food, as well as ground and pressed for the oil. Its cultivation in the Southern United States is attributed to the negroes, who are said to have brought the seeds from Africa (Wood). The introduction of the oil into the Pharmacopœia may serve to encourage its manufacture and use in the United States, but the principal oil crop of the South must necessarily be from the seed of the cotton plant, which, as a by-product of cotton-farming, is produced in enormous quantity.

Benné oil is a light-yellow, limpid oil, of a bland, agreeable taste, and no odor. Its specific gravity is about 0.920. At about the freezing-point of water it begins to be cloudy; at 23° F. it solidifies. Treated with sulphuric and nitric acids it turns first green, then brownish red. It is not really a drying oil, but has some of the qualities of the drying oils.

USES.—It has no medical properties not common to all the fats, and is simply to be regarded as an article of food so far as its internal use goes. In countries where it is abundant it is put to all the uses of other oils—food, fuel, etc. Used externally in liniments, ointments, and plasters, it is a fair substitute for the more expensive olive oil.

ALLIED PLANTS.—The genus and order are both small, and contain no other plants of special interest. Botanically they are related to the *Bignoniaceæ.*

ALLIED DRUGS.—All the simple fixed oils (see OLIVE OIL). The leaves of Benné are very mild and mucilaginous, and demulcent drinks may be made from them having the qualities of quince, flaxseed, slippery elm, mucilages, etc. *W. P. Bolles.*

BENZENE. Benzene, also called *benzol*, is the simplest hydrocarbon of the aromatic series, having the formula C_6H_6. It is, thus, a definite chemical compound, and must be carefully distinguished from *benzin*, a composite substance obtained as a distillate from coal-oil (see Benzin). Benzene or benzol is a thin, colorless fluid, very volatile and very inflammable, and when pure, of a not disagreeable aromatic odor. It is practically insoluble in water, but dissolves in four parts of alcohol. It may be obtained by distilling a mixture of benzoic acid and lime, or by fractional distillation of the material known as *coal-naphtha*, a derivate of coal-tar.

Benzene is of more pharmaceutical than medicinal value. In the former regard its notability is its extensive solvent power, such comparatively insoluble substances as india-rubber, gutta-percha, sulphur, phosphorus, iodine, many resins, and many alkaloids dissolving readily in it. Physiologically, benzene has little local effect, but taken internally determines intoxication, coma, and anæsthesia. Like carbolic acid, to which in chemical constitution benzene is closely related, it is antiseptic and destructive to the life of parasites. It has been given internally in doses of a few drops in dyspepsia, associated with fermentation of the ingesta, and also in trichinosis, but is rarely employed and is not officinal in the U. S. Pharmacopœia. *Edward Curtis.*

BENZIN. Under the title *Benzinum*, Benzin, the U. S. Pharmacopœia makes officinal the substance commonly known as *petroleum benzin* or *petroleum ether*. It is thus defined and described: "A purified distillate from American petroleum, consisting of hydrocarbons, chiefly of the marsh-gas series [C_5H_{12}; C_6H_{14}, and homologous compounds], having a sp. gr. from 0.670 to 0.675, and boiling at 50° to 60° C. (122° to 140° F.). Benzin should be carefully kept in well-stopped bottles or cans in a cool place, remote from lights or fire. A transparent, colorless, diffusive liquid, of a strong characteristic odor, slightly resembling that of petroleum, but much less disagreeable; neutral in reaction; insoluble in water, soluble in about six parts of alcohol, and readily so in ether, chloroform, benzol, and fixed and volatile oils. It is highly inflammable, and its vapor, when mixed with air and ignited, explodes violently" (U. S. Ph.).

Much confusion arises from the similarity in name and general appearance between this substance—a mixture of hydrocarbons of the marsh-gas series—and the chemical body *benzene* or *benzol* (C_6H_6), a single hydrocarbon of the aromatic series (see Benzene). The two articles must be carefully distinguished.

Benzin is not used in medicine, but is useful to the pharmacist for its solvent powers over fats, resins, volatile oils, and other bodies. *Edward Curtis.*

BENZOIC ACID AND BENZOATES. *Benzoic Acid*, $HC_7H_5O_2$, formerly known as *flowers of benzoin*, is a monatomic acid of the aromatic series, existing ready formed in a number of balsams and gum-resins, notably in benzoin, and also easily obtainable, artificially, by decomposition of hippuric acid and of derivates of toluol. The benzoic acids of commerce are derived from all three

of these sources, but the principal supplies are from the former two. Benzoic acid from benzoin is characterized by a special degree of lightness and fluffiness, and by a distinct benzoin odor. The acid derived from hippuric acid is manufactured out of the urine of cows and horses, and formerly was distinguishable by a urinous odor, but as at present made is quite pure and entirely free from such smell. The acid from this source is commonly known, commercially, as *German benzoic acid.*

Benzoic Acid is officinal in the U. S. Pharmacopœia under the title *Acidum Benzoicum,* Benzoic Acid. The source of the article is not prescribed. The acid is thus described: "White, lustrous scales, or friable needles, permanent in the air, having a slight aromatic odor of benzoin, a warm, acid taste, and an acid reaction. Soluble in 500 parts of water and in 3 parts of alcohol, at 15° C. (59° F.); in 15 parts of boiling water, and in 1 part of boiling alcohol; also soluble in 3 parts of ether, in 7 parts of chloroform, and readily soluble in disulphide of carbon, benzol, benzin, and oils. When strongly heated, the acid is completely volatilized. . . . The acid is freely soluble in solutions of potassa, soda, or ammonia. . . . The acid should not have an odor resembling that of bitter almonds, or of stale urine" (U. S. Ph.). From the above remarks concerning the proper odor and absence of odors of the officinal acid, it may be inferred that the intention is to recognize only the article obtained from benzoin. And since the acid of that source can now be had quite cheap, there is no reason for the use in medicine of the other varieties, although it is proper to say that an acid made from horse-urine, if free from smell, is perfectly pure and decent for medicinal prescription. Benzoic acid from toluol, characterized by an odor like that of bitter almonds, is probably not pure, and is unadvisable for medical use.

As to effects upon the animal system, benzoic acid is locally irritant to sensitive surfaces, its concentrated vapor, if inhaled, causing violent sneezing and coughing, and even bronchial inflammation. Yet, when swallowed, benzoic acid is singularly innocent. Even gram doses cause but a feeling of abdominal warmth and increase of bronchial mucus, and serious derangement is scarcely possible by any likely dosage, intentional or accidental. The medicinally important action of benzoic acid is upon the urine. Under the influence of the drug, given by the mouth, an acid urine tends to be of increased acidity, an alkaline to become acid, and a urine prone to decompose before voidance to lose such tendency. The increased acidity of urine determined by benzoic acid is mainly accounted for by the presence in the secretion of hippuric acid, undoubtedly derived, by chemical change, from the benzoic acid itself. This conversion of benzoic into hippuric acid is probably wrought in the kidneys (Meissner and Shepard). Arrest of putrefaction in urines by benzoic acid is probably simply an example of the general antiseptic action of the drug. Opposite statements have been made by investigators concerning the influence of benzoic acid, taken medicinally, upon urinary excretion of urea and uric acid, some finding the proportion of one or other of these excreta to be lessened, and others observing the same to be unaffected.

Besides the action upon the urine, benzoic acid is important for its antiseptic power, in which it probably stands on a par with salicylic acid.

The therapeutic applications of benzoic acid are principally the internal giving of the acid under its own form for the acidifying of the urine in cases where that secretion tends to be alkaline and unduly phosphatic, or for the prevention of decomposition of the urine in the bladder in cases of vesical catarrh. The acid may also be used as an antiseptic. In saline combination, principally as sodium benzoate, benzoic acid has also been employed in acute rheumatism, as an innocent but therapeutically effective substitute for salicylic acid or the salts thereof (Senator), and in pulmonary consumption, diphtheria, scarlet fever, and other diseases of that category. In the latter applications, however, the reputation of the medicine is, at the present writing, decidedly on the wane.

For its legitimate use in urinary disorders, benzoic acid may be given several times daily in doses of from 0.65 to 2.00 Gm. (ten to thirty grains), administered in pill form, with soap as the excipient, or given in mixture. Free solution of benzoic acid in water can be determined by the addition of four parts of sodic phosphate or one and a half part of borax. Solutions for antiseptic purposes should range from two per cent. strength upward, solution in water being effected by the additions just cited.

BENZOATES.—Such of the benzoates as are used in medicine being employed for the sake of the benzoic acid of their composition, their discussion belongs to this place. The benzoates officinal in the U. S. Pharmacopœia are the *sodic, lithic,* and *ammonic* salts.

Sodic Benzoate, $NaC_7H_5O_2$, H_2O. This salt is officinal as *Sodii Benzoas,* Benzoate of Sodium, and is described as "a white, semi-crystalline or amorphous powder, efflorescent on exposure to air, odorless, or having a faint odor of benzoin, of a sweetly astringent taste, free from bitterness, and having a neutral reaction. Soluble in 1.8 part of water and in 45 parts of alcohol at 15° C. (59° F.); in 1.3 part of boiling water and in 20 parts of boiling alcohol. When heated, the salt melts, emits vapors having the odor of benzoic acid, then chars, and finally leaves a blackened residue of an alkaline reaction, which imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). The salt should be kept in well-stopped bottles. Sodic benzoate is made by treating a sodic carbonate, in hot saturated aqueous solution, with benzoic acid, and the quality of the salt will be determined by the quality of the benzoic acid used in its manufacture. The article described by the Pharmacopœia is intended to be made from benzoin-benzoic acid. Specimens made from hippuric-benzoic acid and from toluol benzoic acid have been found to be less freely soluble in water than the above, and to yield pale-yellow and turbid solutions of an acrid, bitter taste, and of an odor of horse-sweat or of bitter almonds, according to the source of the benzoic acid.

Physiologically, sodic benzoate is about as harmless as a salt can be, but has been found to produce fully the curative action of benzoic acid itself in acute rheumatism, and has been loudly vaunted as of wonderful avail in pulmonary consumption, diphtheria, etc. It has been given internally in doses amounting to from 5.00 to 20.00 Gm. (75 to 300 grains) a day, without serious derangement, and for pronounced effect in acute rheumatism the fullest limit of such dosage may be necessary. In diphtheria, inhalations of atomized spray and insufflations of the powdered salt upon the diphtheritic patch have also been practised.

Lithic Benzoate, $LiC_7H_5O_2$. The salt is officinal as *Lithii Benzoas,* Benzoate of Lithium. It is thus described: "A white powder, or small, shining scales, permanent in the air, odorless, or having a faint benzoin-like odor; of a cooling and sweetish taste, and a faintly acid reaction. Soluble in 4 parts of water and 12 parts of alcohol at 15° C. (59° F.); in 2.5 parts of boiling water, and in 10 parts of boiling alcohol. When heated, the salt fuses; at a higher temperature it chars, emits inflammable vapors having a benzoin-like odor, and finally leaves a black residue of an alkaline reaction, and imparting a crimson color to a non-luminous flame" (U. S. Ph.). Lithic benzoate is made by direct decomposition of lithic carbonate of benzoic acid; and, as in the case of the making of sodic benzoate, benzoin-benzoic acid should be used for the manufacture.

Lithic benzoate is an innocent salt, seemingly yielding to a certain degree similar results to benzoic acid itself in urinary affections (see under Benzoic Acid, *ante*). It has been used in such conditions in the place of the uncombined acid, in doses of from 1.00 to 2.00 Gm. (15 to 30 grains) several times daily.

Ammonic Benzoate, NH_4, $C_7H_5O_2$. The salt is officinal as *Ammonii Benzoas,* Benzoate of Ammonium. It is thus described: "Thin, white, four-sided, laminar crystals, permanent in the air, having a slight odor of benzoic acid, a saline, bitter, afterward slightly acrid taste, and a neutral reaction. Soluble in 5 parts of water and in 28

parts of alcohol at 15° C. (59° F.); in 1.2 part of boiling water and 7.6 parts of boiling alcohol. When strongly heated the salt melts, emits vapors having the odor of ammonia and of benzoic acid, and is finally wholly dissipated" (U. S. Ph.). The salt is made by adding benzoic acid to water of ammonia, and again, as with the foregoing salts, benzoin-benzoic acid should be used in the making.

Ammonic benzoate is an innocent salt, and affects the urine after the manner of benzoic acid itself. It is used in place of the acid in urinary disorders (see *Benzoic Acid*, above), in doses of from 1.00 to 2.00 Gm. (15 to 30 grains) several times daily. It amounts, medicinally, to a soluble form of benzoic acid, and can be readily made extemporaneously in solution by chemically saturating benzoic acid with water of ammonia. Let the amount of benzoic acid to be prescribed be mixed with a little water, then neutralized with water of ammonia, and the whole brought to a desired volume of solution by further addition of water (Squibb). *Edward Curtis.*

BENZOIN (*Benzoinum*, U. S. Ph., Br. Ph.; *Benzoë*, Ph. G.; *Benjoin*, Codex Med.; Siam and Sumatra varieties; Gum Benjamin, English trade name). The derivation of this familiar word is thus curiously traced by the authors of the "Pharmacographia:" "The word Java was at that period (fourteenth century) a designation of Sumatra, or was even used by the Arabs to signify the islands and productions of the Archipelago generally. Hence came the Arabic name *Lubân Jâwi, i.e., Java Frankincense,* corrupted into *Benjawi, Benjui, Benzui, Benzoë,* and *Benzoin,* and into the still more vulgar English *Benjamin.*"

The botanical source of *Sumatra* Benzoin was first made known by Dryander; the sources of Siam and Penang benzoins are still in doubt, but most probably belong to the same genus, if they are not really identical with the plant yielding the first-named variety, viz., *Styrax Benzoin* Dryander. This is a medium-sized tree, with a trunk as thick as a man's body, and a fine spreading crown. The branches and the under surface of the leaves are velvety or hairy, the hairs often stellate. The leaves are of medium size, simple, alternate, petiolate, ovate-acuminate, nearly or quite entire. The flowers are two and a half millimetres long, in small terminal and axillary cymes. They are regular, bell-shaped, perfect; calyx five-toothed, or nearly entire; corolla spreading, five-parted. Stamens ten, inserted on the corolla and united at the base; ovary nearly free, three-celled at the base, the cells communicating with each other above. Seeds several; fruit globular, one-celled, one-seeded by the abortion of the remaining ovules. The tree contains an abundance of resinous fluid, which is found mostly in the middle layers of the bark and in the medullary rays of the stem. It grows in Sumatra, Java, Borneo, and the Malaysian Islands. In the former it is planted and rudely cultivated for benzoin. It has also been introduced into Brazil, where it flourishes and yields its resin.

Benzoin is not, so far as a European knowledge of it goes, a very ancient medicine. It was noticed by an Arabian traveller in the middle of the thirteenth century, but the first portion reached Europe, as a present to one of the Doges of Venice, about a hundred years later. For one or two centuries more it was only an occasional rarity; but with the more direct communication with the East, brought about by the East India Company, and Spain and Portugal, it came more regularly and abundantly, and for the past hundred years has been comparatively plentiful and cheap.

The trees in Sumatra are planted around the borders of rice fields, and are allowed to grow without interference until they are five or six years old, and have a diameter of twenty centimetres. Then the bark is gashed and a white, resinous sap flows out, and hardens into large white tears. The best sort of benzoin is produced by these young trees, for, gradually, as the tree is drained year after year, the resin becomes inferior and brownish. After about twenty years only the smallest yield of very dark balsam is obtained; then the trees are felled, and the final crop is obtained by splitting and scraping the wood. In Siam the trunks are said to be beaten, by which means the resin is made to flow into the contused tissues, and it is afterward collected by stripping off the bark. Neither of the above accounts is very full or satisfactory, and no explanation is given of the peculiar mixture of tears and matrix which the balsam usually displays. This is probably the result of pouring the darker balsam, in a soft state, into heaps or masses of the harder, light-colored tears, or in some way running them together.

Among the Malays, who collect it, benzoin is graded in three sorts—the best in light lumps or tears from the younger trees, the second quality from the older, and the third obtained by scraping the wood of those which have been cut down. These grades have received the barbaric, but expressive, names of *head, belly,* and *foot* benzoin.

Benzoin is usually imported in boxes, into which it has evidently been put in a more or less soft condition. It varies considerably in appearance, but consists essentially of opaque white or light brown, so-called tears, embedded in a gray, brown, or amber-colored and translucent (Siam variety) mass, and mixed with a variable amount of bark and chips. The relative amount of the above portions varies greatly, and with it the price of the drug. Some fine samples consist of tears only, either loose or merely agglutinated together in a porous mass; others, apparently of the gray resin only; and finally, samples are occasionally seen consisting mostly of sawdust and bark. It is always dry and brittle when it arrives here, breaking with a dull, resinous fracture. It has a weak, "balsamic" odor, increased by warming, and has very little taste. In our markets it is usually divided, according to the country whence it comes, into two or three varieties. The cheapest, and by far the most abundant of these, is *Sumatra Benzoin.* It comes in solid, ponderous blocks (casts of the boxes in which it is packed), bearing a striking resemblance to very coarse brownish-gray Scotch granite, or to the interior of the bars of mottled Castile soap. The white lumps are from the size of a nutmeg down to that of a pinhead, averaging, perhaps, as large as peas, but variable; in some specimens they are very minute, and even apparently absent, in others large and conspicuous. The interstitial mass has a mixed-gray color. Both portions become browner by age. Old pieces exposed to light and air assume a general yellowish-brown surface color, in which it is difficult to distinguish the tears from the matrix. This variety is less fragrant than the following ones, but is the one usually used for medical purposes, at least in this country. *Penang Benzoin,* often spoken of as a variety of the above, resembles it in appearance, but is often much handsomer, with large, well-defined white spots, and gray matrix. Its odor is distinctive, resembling that of styrax, from which peculiarity it is sometimes called styrax-smelling benzoin. *Siam Benzoin* is comparatively rare and costly, being valued from four to eight times higher than the Sumatra. Inferior sorts of it resemble this variety in appearance, but are browner and more fragrant; they are often quite dirty. The finest examples consist of entirely separate, or only loosely cohering tears, often as large as almonds, sometimes much larger. At first they are white and opaque, but become cinnamon-brown and slightly translucent upon the surface by exposure. The odor is delicious and vanilla-like. It is mostly used as a perfume.

Benzoin gives up a little *benzoic acid* to water, but is otherwise insoluble in it; it is freely and completely soluble in alcohol and in potash solution (impurities excepted), but only partially so in ether. It consists of *benzoic* (and sometimes *cinnamic*) *acid,* several *resins,* and a minute portion of essential oil.

Benzoic Acid (*Acidum Benzoicum,* U. S. Ph.) was known more than two hundred years ago as *Flores Benzoë.* It exists free in Benzoin, to the extent of from fourteen to eighteen per cent., and may be obtained by washing the resin with lime-water, or by distillation. That obtained in the latter way always retains the odor of the drug, and is the kind required by the Pharmacopœia; probably to prevent the substitution of the cheaper German acid, prepared from the urine of horses and cattle, for that pre-

pared from the "gum." It is in pearly white, flaky scales, or in needles; with an agreeable odor, and a faintly sour, rather warm and aromatic taste. It dissolves sparingly in water, and freely in the other pharmaceutical liquids (alcohol, ether, oils, etc.). It is easily volatilized, its vapor pleasant smelling but irritating to the bronchi. Several salts of the acid are used in medicine. The *amorphous resins* of Benzoin are at least four in number, and yield a further amount of benzoic acid by destructive distillation. An alcoholic varnish of fine lustre, but having little body, is made from these resins (or from Benzoin itself) for cabinet uses. The *essential oil* (styrol ?) is in very minute quantity. Many lots of benzoin contain a considerable amount of *cinnamic acid*—indeed specimens have been found to yield only this acid, and no benzoic. Sumatra and Penang varieties generally contain it; the new Palemb Benzoin is said to be free from it. The Pharmacopœia requires a drug containing no cinnamic acid. It is doubtful if this requirement is complied with. The tears are said to contain less benzoic acid than the gray resin, their melting point is also a little lower; otherwise no chemical difference is known between them. Siam Benzoin contains a little *vanillin* in addition to the other constituents.

Action and Uses.—Benzoin itself is never given internally in sufficient doses to arouse any special physiological disturbance. Of its various constituents, the acid is probably the only one having any activity; and even this can be taken in comparatively large amounts, without producing any more interesting phenomena than nausea, vomiting, feeling of warmth in the bowels, increase of pulse, etc. It undoubtedly will reduce the temperature. Given in fatal doses to warm-blooded animals, the following symptoms have been observed: trembling, convulsions, paralysis, first of the extremities, later of the entire body; vomiting, gastric hæmorrhages; at first acceleration, and finally, retardation and depression of the circulation and respiration, collapse, death by asphyxia. The dose required was $\frac{1}{2000}$ of the weight of the animal.

Benzoic acid is easily absorbed and eliminated, mostly from the kidneys—traces of it being found, however, in the secretions of the skin and salivary glands. It does not appear to be decomposed in the blood, but in its passage through the kidneys it unites with some nitrogenous material, and is eliminated as hippuric acid. The manner in which this is done, the source of the nitrogen, and the therapeutic value of the procedure, are unsettled points. That it does increase the acidity of the urine in phosphaturia, and that it, at least in some cases, is beneficial in chronic vesical catarrh is generally admitted. Benzoin has long been used as a preservative for lard and ointments; but its general antiseptic value, as shown by its poisonous action upon bacteria and other microscopic agents of putrefaction, was first observed by Dougall in 1872, since which time it has been extensively used, both experimentally and therapeutically, with this view. A solution of one part in a thousand has been found sufficient to prevent the development of, and one of four parts *per mille* to destroy, bacteria and micrococci. Since this discovery Benzoin and its acid have been used in many diseases which are known or suspected of having some relation to the development of micro-organisms, generally with good, if not very striking, results. In diphtheria, in erysipelas, in inflammation of the bladder with decomposing urine, and in gonorrhœa, it is worth trying. As a local remedy for washing-out the bladder, vaginal injections, and surgical dressings, it has undoubted value. Empirically it has been used for rheumatism, in cough-mixtures as an expectorant, also in nocturnal emissions, etc., but for such purposes is obsolete. The fumes of benzoic acid are sometimes inhaled in the treatment of chronic bronchitis. Pastiles may be made with benzoin for the same purpose. Benzoin is an ingredient of the incense used in Roman Catholic, Greek, and other religious ceremonies.

Preparations.—Benzoin itself can be given in substance as a pill or powder, or as an emulsion, made by rubbing it up in water or syrup. From two to four grammes would be a fair dose; it is, however, almost never given in such a manner. The Tincture (*Tinctura Benzoini*, U. S. Ph., strength $\frac{1}{5}$), and the Compound Tincture (*Tinctura Benzoini Composita*, U. S. Ph.: Benzoin, 12; Purified Aloes, 2; Storax, 8; Balsam of Tolu, 4; alcohol, enough to make a hundred) are mostly used externally; the latter is essentially the old *Balsamum Traumaticum*, and, under various other names, as "Friar's" or "Wade's" Balsam, "Jesuits' Drops," etc., has long been a favorite vulnerary. Within a few years this tincture has been used as an antiseptic dressing in minor surgery. For small, clean cuts and wounds that can be left undisturbed until they are well; for the openings of compound fractures that need only to be sealed; for cuts, or operations of small size that have been stitched, and where healing by first intention is expected, there is no better dressing. But for large granulating surfaces, or for large wounds of any kind, it is not very comfortable or safe. As it is not miscible with water, the parts should be made aseptic, and carefully dried by some suitable means before its application. Then a dressing of absorbent cotton and bandages should be put on *dry*, and when all is done the Compound Tincture should be poured upon it until it is saturated. When this has become dry it may be again filled with tincture, and then again, or until it dries into a hard crust over the wound, where it may remain as long as the injury appears to be doing well, or until it is recovered from. When the dressing needs changing it should be softened with *alcohol*, not water, after which it can be easily unrolled.

Benzoinated Lard (*Adeps Benzoinatus*, U. S. Ph.) consists of lard that has been melted with a little Benzoin, which acts as a preservative. All preparations in which Lard is used are made with it.

Benzoic Acid (*Acidum Benzoicum*, U. S. Ph.) or rather its salts (*Ammonii, Sodii, Lithiæ Benzoas*, U. S. Ph.), are frequently used internally. The acid itself is not so often prescribed, on account of its insolubility in water. The ammonium and sodium compounds may be taken to represent it almost exactly. The Lithium Salt contains a full dose of that base in addition. From one to two grammes of either may be given, of the two first even more. For rinsing the bladder a one *per mille* solution of the acid is strong enough; for surgical washes a saturated one (one to five hundred).

Allied Plants.—The botanical relations of Benzoin are not particularly interesting from a medical point of view. The order is a small tropical one, of which *Styrax* is one of the principal genera. This genus comprises about sixty species of trees and shrubs, most of which are natives of tropical parts of Asia and South America. Several of them yield resinous or balsamic products. *S. officinale* Linn., a small tree of the Levant, is the source of the true Styrax of Dioscorides, no longer used. S. *aureum* and one or two other Brazilian trees yield resins, which are collected there for home use. *S. subdenticulata* Miq. of Sumatra, is suspected also to be a source of Benzoin.

Allied Drugs.—The nearest related drugs are the other balsams, properly so called. These are *Tolu, Peru, Styrax, Acaroides*, etc., and are characterized by their mild and agreeable odor, and by the presence of either Benzoic or Cinnamic Acid. Wider removed, but still to be classed with them in many respects are the gum-resins: *Myrrh, Olibanum, Ammoniac*, etc.; and still farther away stand the turpentines, and the so-called balsams of *Fir, Copaiba, Gurjun*, etc., none of which contains benzoic acid. This acid is found, on the other hand, in numerous other plants and products, where it is an incidental constituent. Thus it is found in *Dragon's-blood, Sweet-flag root, Elecampane*, the oils of *Cinnamon, Bergamot*, in *Clove-fruits, Vanilla*, etc. It is further formed by the decomposition of oil of bitter almonds, and other fragrant substances, and is also largely manufactured from *horses' urine* and from *Naphtalin* for use in the arts.

The following more or less related substances are used as antiseptics: *Thymol, Creasote, Methyl, Salicylic Acid, Salicin, Phenol* (Carbolic Acid), etc., but none of them equals in germicide power the *Bichloride of Mercury*, which at present stands at the head of the list of antiseptics.

W. P. Bolles.

BERCK-SUR-MER. A sea-coast village in the Department of Pas-de-Calais, France, lying upon the shore of the English Channel. This place is only mentioned in order to call attention to the sea-side hospital there existing, and having accommodations for five hundred patients. Lombard tells us in his "Traité de Climatologie Médicale," vol. iv., p. 604, that this hospital was established in 1870, in consequence of the excellent results in the treatment of cases of scrofula and rickets obtained at the hospital, containing one hundred beds, that had been founded at this place by the city of Paris for the use of the poor. The present hospital contains eighty beds, intended for the children of such parents as can afford to pay the small sum of one franc eighty centimes (thirty-six cents) *per diem* for their board, lodging, and medical treatment. The idea of founding such establishments for the benefit of poor children, the victims of scrofula and kindred diseases, appears to have originated with the Italians; and Dr. Lombard alludes (op. cit., pp. 602, 603) to no less than eight such charitable institutions existing upon the Mediterranean and Adriatic shores of the Italian peninsula. The reports of these hospitals, he tells us, show excellent results from this most admirable and commendable charity. At Biarritz and at Cette, as well as at Berck-sur-Mer, the French have made more provision for this class of patients. *H. R.*

BERGAMOT, OIL OF (*Oleum Bergamii*, U. S. Ph.; *Bergamote*, Codex Med., the rind of the fruit). The Bergamot tree, *Citrus Bergamia* Risso, Order, *Rutaceæ*, is a small evergreen, very much like the bitter orange in almost all respects, but the leaves are obovate, with narrowly winged petioles, and the flowers are smaller and fewer. It is not known in a wild state—indeed, it was not known at all until about two hundred years ago, when it appeared in the south of Europe. There is no doubt it is a hybrid or cross of some kind, probably between the bitter orange and the lemon or citron. The fruit is about as large as a small orange, and has the same general structure. It is rounded, pear-shaped, about as broad as long, with a broad, flat, or even depressed apex; the skin is soft, smooth, yellow, and very fragrant. The pulp is sour and bitter.

Bergamots are raised in the vicinity of Reggio, in the south of Italy, and Sicily, and the oil is exported from Messina and Palermo. This is collected mechanically by rupturing the vesicles, sometimes by the old sponge process used with oranges and lemons in obtaining their oils, but more generally now by a sort of hand-mill, into which the fruits are put whole, and rolled and rubbed against a series of knives, which cut or scrape the surface and so liberate the oil. It flows to the bottom of the mill, and out through suitable apertures. One hundred fruits yield two and a half or three ounces of the oil (Flückiger).

It is a thin, mobile, pale-green, or greenish liquid, with a very fragrant, pleasant odor, and a bitter, aromatic taste. Its specific gravity is 0.85 to 0.88; its reaction slightly sour. It consists of one or two terpenes and related oxygenated oils. Like the essential oils in general, it dissolves readily in alcohol, chloroform, ether, and fats, and only very sparingly in water. The green color is due to chlorophyl.

The medical properties of Oil of Bergamot are those of essential oils in general, but it is never used internally. On the other hand, its delicious odor has made it a universal favorite in perfumes and toilet preparations. The world-renowned Cologne water has it as its principal ingredient, modified by other aurantiaceous oils. There are numerous formulæ for making it; one is officinal (*Spiritus Odoratus*, U. S. Ph.), and given below:

"Oil of Bergamot	16 parts.
Oil of Lemon	8 "
Oil of Rosemary	8 "
Oil of Lavender Flowers	4 "
Oil of Orange Flowers	4 "
Acetic Ether	2 "
Water	158 "
Alcohol	800 "
	1,000 parts.

"Dissolve the oils and the acetic ether in the alcohol, and add the water. Set the mixture aside in a well-closed bottle for eight days, then filter through paper in a well-covered funnel."

It improves by being kept for several months.

Allied Plants.—See Orange.

Allied Drugs.—Inferior products are obtained by distilling the rinds, and even the leaves of the tree; they are used as substitutes or adulterants of the better oil. Citric acid is obtained from the pulp. *W. P. Bolles.*

BERIBERI. Synonyms: Hydrops Asthmaticus (Rogers, 1808); Synclonus beriberia (Mason Good); Beriberia.

Definition.—"A disease characterized by anæmia, anasarca, degeneration of muscular tissue, effusion into serous cavities, debility, numbness, pain, and paralysis of extremities, especially the lower; precordial anxiety, pain, and dyspnœa; scanty and high-colored urine, and, in some cases, drowsiness or sleepiness. Beriberi occurs in a chronic and an acute form, in the latter often proving rapidly fatal from exhaustion, syncope, or the formation of cardiac or pulmonary coagula" (Fayrer).

Etymology.—1. The word *beri* is stated, in the Sin ghalese language, to imply weakness, debility, or disease. The repetition of the word *beri* conveys the idea of greater intensity. 2. From the Hindu word *Bheree* (a sheep), from the fancied resemblance of the gait of patients suffering from this disease to that of sheep. 3. A Hindu word *Bhèr-bheri*, signifies a sore or swelling. 4. The disease being prevalent among African and Arab sailors, it has been suggested (Carter) that the derivation is from *Bhari*, a sailor; *Bahr*, the sea, and *Bhayr*, shortness of breath.

Geographical Distribution.—Beriberi occurs endemically in Ceylon, India, Malabar Coast, and in the Northern Circars between 13° and 20° north latitude—extending inland some forty or fifty miles—Burmah, and the Malayan Peninsula. Madras appears to be the southern limit of the disease. It is prevalent among the crews of ships trading to ports in the Persian Gulf, Red Sea, coast of Africa, Bay of Bengal, Singapore. It has been observed also in South America, Japan, and Australia.

Pathology.—It appears most probable that Beriberi is essentially the same disease as pernicious anæmia, modified by climatic influences. The majority of symptoms are directly or indirectly the result of anæmia, those referable to the nervous system being the result of a supply to the spinal cord of blood poor in quality; hence the peculiar form of paralysis which occurs in the later stages of the disease. Inflammatory changes do not occur in any of the organs.

Etiology.—It has been stated that beriberi is found in warm climates only, and that it is essentially endemic, its distribution extending not more than sixty miles from the shore. It occurs independently of miasmatic influences. Malaria, by inducing a general cachexia, may indirectly predispose. It is necessary for the development of beriberi that the patient should have resided from eight to ten months in the district where it prevails.

The disease usually attacks adults, and, by preference, those who follow sedentary occupations. The intemperate, and those debilitated from any cause, are especially liable. It is more prevalent among natives than among Europeans. Malcolmson thought that more Mussulmans than Hindus were attacked.

Anatomical Characters.—The principal morbid change is serous effusion, causing œdema, at first, of the lower extremities, afterward of the whole body, with effusion into serous cavities, most frequently into the pericardium (Aitken). The kidneys are enlarged, anæmic, and softened. The paralysis usually present is accounted for by the alterations found in the spinal cord, there being minute effusion into its substance, as well as pressure by superabundant fluid upon its surface.

Symptoms.—Most writers are agreed in describing three varieties of the disease—the acute, the subacute, and the mild form. It will suffice in this limited space to describe but one form, the acute.

The disease sets in usually with rapidly increasing anæmia and general anasarca. There is a sensation of

numbness in the feet and legs, which renders the gait unsteady, and which is soon followed by paralysis of the lower extremities. Hæmatemesis and melæna occasionally occur, the bowels being usually constipated. There is disturbance of the heart's action, dyspnœa, and palpitation. The pulse is frequent and shabby. Anæmic murmurs are sometimes present. The circulation is feeble, the extremities cold; the urine is scanty, dark, its specific gravity 1.020 to 1.040. Albumen and sugar are not present.

This acute form of beriberi has been known to have proved fatal in a few hours, but most commonly its duration is prolonged over several weeks. A fatal result occurs, in most instances, suddenly, with symptoms of rapid effusion into serous cavities, the immediate cause of death being thrombosis of the pulmonary vein.

The acute often supervenes upon the mild form, or attacks those who are suffering from any cause of general debility.

In the acute form the fatality is very great, but in the milder varieties recovery often occurs.

Among European soldiers in India, the ratio of mortality or death to admissions from beriberi, is about twenty-six per cent., and among Sepoys it is nearly fourteen per cent. In jails the percentage is as high as 36.5 (Waring, quoted by Aitken).

TREATMENT.—Of this little can be said. The measures for the prevention of beriberi consist chiefly in protecting the body from exposure to the weather, from cold as well as from malarial emanations. Tonics and stimulants are indicated, though iron and quinine fail in their specific action. For the relief of the œdema and dropsical effusions, diaphoretics and diuretics should be given.

R. L. MacDonnell.

BERKELEY SPRINGS. *Location and Post-Office,* Berkeley Springs, Morgan County, W. Va., via Baltimore & Ohio Railroad, to St. John's Run Station, where coaches will be found to convey guests to the Springs, two and a half miles distant.

There are five principal, and numerous smaller, springs, discharging in the aggregate about two thousand gallons of water per minute, of the uniform temperature of 74° F. They are situated in a narrow valley, 800 feet above the sea-level, and issue from the base of a steep ridge of sandstone of various degrees of hardness, rising about 450 feet above the valley.

ANALYSIS.—All the springs appear to be of a similar composition, as only a general analysis is given, as follows: One pint contains (A. A. Hayes, M.D.):

	Grains.
Calcium carbonate	0.625
Sodium chloride	0.112
Calcium chloride	0.026
Magnesium sulphate	0.045
Calcium crenate	0.455
Ferrous crenate	0.010
Ferrous silicate	0.080
Loss	0.008
Total	1.361

The flow is so copious that, after supplying the numerous private baths and large swimming pools for both sexes, it is utilized for milling purposes, further down the valley. In the neighborhood, issuing from the base of the same ridge, are several other springs possessing valuable tonic qualities.

THERAPEUTIC PROPERTIES.—These are valuable thermal waters, and, used in the form of baths, have proved efficacious in cases of rheumatism and neuralgia. Taken internally they are diuretic and tonic.

HISTORY.—The medicinal qualities of these springs were first made known to the early settlers in Virginia by the Indians, who had resorted to them for relief from various ills, especially rheumatism. In 1777, the General Assembly of Virginia having passed an Act for that purpose, the town of Bath at the Warm Springs was laid off, and among purchasers of lots were Generals Washington and Gates, Baron Fairfax, and other notables of the period.

The hotel accommodations are excellent, and facilities for bathing and recreative amusement are provided. The surrounding country, mountainous and extensively covered with primeval forests, affords delightful drives and walks. There is also excellent hunting and fishing. The air is pure and salubrious, the temperature during the day averaging about ten degrees below the record in cities nearer the coast, while the nights are cool enough to make a blanket very agreeable.

The village contains churches of various denominations and good schools. *George B. Fowler.*

BERKSHIRE HILLS. The hilly country lying between the nearly parallel ranges of the Hoosac and Taconic Mountains, in the extreme western part of the State of Massachusetts, has long been noted for the beauty of its scenery and for the general healthfulness of its climate, and has become, in consequence, a very favorite and fashionable resort, more particularly for dwellers in the cities of Boston and New York desiring to escape from the heat and vitiated air of a large town during the summer months. Not only do many such persons possess, in and about the chief towns of this region, handsome and attractive homes, where they reside during the warmer months of the year, but a considerable number of the wealthier class reside in this neighborhood throughout the entire course of the year.

The Hoosac range of hills vary in height between 1,200 and 1,600 feet, while Greylock, the highest peak of the Taconics, rises some 3,500 feet above the sea-level. The summer climate of the Berkshire country is cool, and it is claimed that at all seasons a protection is here enjoyed against the dampness brought by easterly winds from the Atlantic and by westerly winds from the Great Lakes, a good part of their load of moisture being deposited by these winds upon the Hoosac Mountains, which form the eastern, and upon the Taconic Mountains, which form the western, boundary wall of the region.

The length of the Berkshire Hill country is about fifty miles from north to south; its breadth from east to west is about fifteen or twenty miles. The following remarks on the healthfulness of the country are quoted from a paper written by Dr. J. F. A. Adams, of Pittsfield, read before the Berkshire District Medical Society, December 27, 1883, and recently circulated in pamphlet form: "The registration reports show that the mortality from consumption is less in Berkshire than in any other county of the State, being but little more than half what it is in some of the maritime counties, and physicians know that of the cases which do occur here, the great majority are factory operatives, whose mode of life renders them peculiarly liable to this disease. . . . The dry atmosphere tends also to the prevention of rheumatism, which is very prevalent along the seaboard. For children the air is extremely favorable, cholera infantum, the summer scourge of cities, being rarely seen, and other summer diseases are comparatively mild. . . . Although malaria was for many years quite unknown in Berkshire, it has, since 1877, existed in a few low places adjacent to reservoirs or swamps. It is now, however, fast disappearing, and the indications are that it will soon become extinct. Those localities which under any circumstances would naturally be selected for a healthful residence have not been invaded, excepting here and there in the immediate vicinity of some marshy spot, and we need not regard this temporary and localized prevalence as an objection to taking up a residence in Berkshire. No part of the world possesses a more enchanting summer and autumn than Berkshire."

The winters in the Berkshire Hill region are decidedly cold, as the figures given below will show; but they are spoken of by the writer just quoted as being "delightful, with a dry, crisp, stimulating atmosphere, and plenty of snow." The severity of its winter seasons would certainly seem to exclude the Berkshire country from the list of places to be recommended as specially fitted for the residence of phthisical patients during the colder months of the year, but the universal testimony borne by residents and by visitors as to the purity and the bracing effect of its atmosphere, would seem to recommend this region as a

place of summer sojourn not only for persons suffering from incipient phthisis, but for those whose general health has suffered impairment by overwork and by prolonged residence in the vitiated air, and amid the social and business excitement, of a great city; while for some persons who are merely "threatened with," or who, perhaps, may have already manifested in slight degree the commencing lesions of pulmonary phthisis, and who cannot go to such places as the Riviera, Davos, Aiken, California, etc., a continued residence among the Berkshire Hills, winter and summer, would be likely to check, and, perhaps, to arrest permanently, the progress of the disease. For such persons it would be a matter of no small importance that, over and above its beautiful scenery and its pure air and generally healthful climate, this particular region is superior to most similar sections of the United States, in that it presents throughout the year the attraction of good social advantages, a good percentage of its resident population being persons of cultivation and refinement.

The short tables herewith subjoined are extracted from those published in "Smithsonian Contributions to Knowledge," Nos. 277 and 222. Table A gives the latitude, longitude, height above sea-level, and average monthly, seasonal, and yearly temperature of five of the chief towns or villages of the Berkshire Country; Table B shows the extreme range of temperature throughout a series of years at one of these places (Williamstown); Table C presents the figures for the average rainfall, in inches, at the same place. *Huntington Richards.*

TABLE A.

Town.	Latitude.	Longitude.	Elevation.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.	Period of Observations. Begins.	Ends.	Extent. yrs.	mos.
Hinsdale	42°27′	73°08′	1,360	24.18	21.15	23.87	42.08	53.65	64.76	69.59	66.27	58.54	43.08	33.00	23.17	39.87	66.87	44.87	22.82	43.61	July, '68.	Dec., '70	2	3
Lenox	42°20′	73°18′	1,000	22.77	16.77	29.92	37.24	51.51	63.27	64.92	64.36	54.62	42.86	32.79	21.93	39.56	64.18	43.42	20.49	41.91	Jan., '37.	Dec., '38	2	.
Pittsfield......	42°27′	73°15′	1,084	.....	23.30	28.20	34.41	.....	64.42	67.28	64.32	57.33	49.11	31.10	26.17	.....	65.84	45.85	.....	.....	1851.	1858	1	3
Richmond....	42°23′	73°22′	1,100	21.80	24.17	30.83	44.01	57.83	68.18	71.57	68.70	62.22	49.55	36.03	25.60	44.22	69.48	49.27	[illegible]	46.71	1851.	Dec., '70	14	10
Williamstown	42°43′	73°13′	686	21.63	22.92	30.93	43.60	55.78	65.56	69.66	66.52	58.81	46.92	30.34	25.28	43.44	67.25	47.36	23.28	45.33	Jan., '59.	Dec., '70	36	8

TABLE B.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.		Period of Observations.	
Williamstown ..	61	61	71	87	95	95	97	96	95	85	72	59	Year of extreme heat, 1820. *	January, 1816.	December, 1870.
"	−30	−26	−12	17	28	35	48	39	25	13	−3	−19	Year of extreme cold, 1835.		

* Also in 1825 and 1826.

TABLE C.

Town.	Lat.	Long.	Elev'n.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Sum.	Aut.	Winter.	Year.	Period of Observations. Begins.	Ends.
Williamstown.	42°43′	73°13′	686	2.47	1.89	2.48	3.09	3.94	2.94	4.79	5.02	3.58	3.60	3.38	3.40	9.51	12.75	10.56	7.76	40.58	Sept., 1854.	Dec., 1867.

BERMUDAS. The Bermuda Islands lie about six hundred miles east of the North American coast, upon a coral reef which rises from the bed of the Atlantic Ocean. The entire group comprises no less than 365 islands, but, with the exception of some twelve or fifteen, they are far too small to be suitable for human habitation, and of these twelve or fifteen inhabited islands, only five or six are of any considerable size. The largest island of the group is that of Great Bermuda, also called Long Island, which has a length of about sixteen miles, and is but one mile and a half broad. When it is taken into account that the whole group of the Bermudas are comprised between Lat. 32° 14′ and Lat. 32° 25′ N., and between 64° 38′ and 64° 52′ W. Long., occupying, therefore, a portion of the earth's surface only 11′ long by 14′ wide, it is easy to understand how closely packed and crowded together these 365 islands and islets must be. The coral reef underlying this little archipelago, and of which its cluster of islands are merely the most prominent portions jutting out above the surface the ocean, extends on their western side for a distance of about ten miles beyond the limits of the islands themselves, and it may well be understood that the navigation of these coasts, and the approach to the Bermudas are extremely dangerous to ships, and that the services of skilled pilots are always required by vessels entering or leaving their harbors. Nevertheless, the art of scientific engineering has so far overcome these natural obstacles, that the harbor of St. George's is now one of the chief naval stations of the British Government, to whom the Bermuda Islands belong. Hamilton harbor, although by no means so large as that of St. George's, is, nevertheless, navigable to vessels of many tons burthen, and is the port of entry for the steamers of the Quebec Steamship Company, plying between Bermuda and New York.

From the various accounts of the Bermudas which the writer has examined, he would infer that the town of Hamilton and its neighborhood were to be preferred as a place of residence by invalids resorting to the islands, the streets of their other chief town, St. George's, being generally very narrow and its drainage rather defective, while the hotel accommodations of the former town appear to be superior to those afforded by the latter.

The porous limestone rock, underlying the thin layer of surface soil which covers the islands, rapidly absorbs all the water which falls upon them from the clouds, so that no marshes are to be found anywhere throughout the extent of the Bermudas. Streams of running water and wells are equally absent, and rain-water alone constitutes the supply for drinking and for washing purposes. The character of the soil is especially suited to the construction of good roadways, hard and smooth, and delightful drives abound in every direction. The facilities for fishing and for yachting are also unsurpassed. The existence of the important naval station at St. George's, insures to the Bermudas, at all seasons, an amount of social gayety, and a resident population possessing a degree of cultivation, not generally to be found in places

having so small a number of inhabitants, and situated so far from the greater centres of civilization. Such being the character of Bermuda society, it is no surprise to learn, as we do from the writer in Appletons' "Handbook of Winter Resorts," that at the town of Hamilton "there are good schools."

In their general appearance and in the character of their scenery and vegetation, the Bermuda Islands resemble their rather distant and more southerly neighbors, the West Indies. Owing, however, to their much greater distance from the equator, the climate of the Bermudas is rather cooler than that of the Antilles, and their vegetation is much less distinctively tropical. The elevation of the surface of the islands above sea-level is by no means great, at no point exceeding two hundred and sixty feet, and they do not, therefore, possess the beauty of outline and dreamily picturesque appearance characteristic of so many of the West India Islands. Indeed, to judge solely from certain pictures of them which the writer has seen (for he has never had the pleasure of visiting the Bermudas), a general view of the whole group, when looked at from a distance, would be suggestive of the Thousand Islands of the St. Lawrence put out to sea rather than of the tropical islands of the Caribbean and Gulf of Mexico. When we read, however (in the "Encyclopædia Britannica"), that "the citron, sour orange, lemon, and lime grow wild" in Bermuda, that "the oleander bush, with all its beauty, is almost a nuisance," so profusely does it grow, and that "coffee, indigo, cotton, and tobacco are of spontaneous growth;" and when, moreover, we are told (by the writer in Appletons' "Handbook," quoting from *Harper's Magazine*) that the mango, guava, papaw, pomegranate, fig, avocado pear, custard-apple, and banana "all grow readily" in Bermuda, and that "tamarind, tamarisk, palmetto, cocoanut, india-rubber, mahogany, and calabash trees are quite common," it is evident that any resemblance which these islands, when seen from a distance, may bear to the little Canadian fresh-water archipelago, would disappear immediately upon a close inspection, and that the Bermudas are isles of the "sunny South" in very truth, and only superficially resemble the distant Thousand Islands of Canada.

The nearest approach to a detailed and exhaustive account of the Bermudan climate which has met the eye of the writer is to be found in Dr. Julius Hann's very excellent "Handbuch der Klimatologie." On pages 608 and 609 of this work the following data of, and remarks upon, the climate of Bermuda are given :—

At St. George's (Lat. 32° 23′ N., Long. 64° 40′ W.) the mean temperature of January, according to Dr. Hann, is 61.8° F.; that of April is 64.6° F.; that of August is 80° F.; that of October, 73.2° F.; while for the whole year the average temperature is 69.6° F. July has a mean temperature cooler than that of August by one-half a degree centigrade (= 0.9° F.), or, in other words, its mean temperature is 79.1° F. February and January have the same mean temperature (viz., 61.8° F.), while the month of March is slightly cooler (61.7° F.). The average yearly extremes of temperature are 91.4° F. and 42.8° F. The relative humidity figure (80 per cent.) indicates a decidedly moist climate, and in this factor of climate there is but little variation in the Bermudas throughout the course of the year. The sky is apt to be largely covered by clouds, the figures showing the percentage of sky surface thus covered, deduced from an average of the observations made, being 64.0 for the year, 70.0 for the winter season, and 53.0 for the month of August. The annual rainfall is 50 inches (on Ireland Island 54.72 inches), and this total amount is pretty evenly distributed throughout the twelve months of the year, the month of October being, however, the most, and the months of April and June the least, rainy. The figures for the separate months are not given by Dr. Hann. Quoting from an anonymous writer in the *Nautical Magazine*, he describes the climate of the Bermudas as "one of the most debilitating to be found in the whole world, being, as it were, a mixture of the fogs of Newfoundland with the siroccos of Madeira." This writer goes on to give a detailed account of the effects produced by the warm fog upon the wearing apparel of the traveller visiting Bermuda during the prevalence of a southerly wind, which forcibly recalls what many who have crossed the Atlantic in mid-summer would recognize as having fallen within the domain of their personal experience. Such veritable Turkish-bath weather is not unpleasant to some persons, but it can hardly be considered as especially health-producing. Another writer quoted by Dr. Hann speaks of the month of June as being the most agreeable of all the twelve in Bermuda, while the heat during the four months from July to October, inclusive, is very oppressive, especially during the two months of August and September; but he adds that sickness is less common at this particular season than during any other portion of the year, with the exception only of the winter season. This exception is a very important one for the consideration of invalids and their physicians, as it is only during the colder months of the year that invalids from the so-called temperate regions of the earth would be likely to think of visiting the Bermuda Islands.

The writer last mentioned, as quoted by Dr. Hann, tells us that snow occasionally falls in the Bermudas; but it is very easy to believe him when he adds that it "never remains on the ground for any length of time." For some residents of the northern portion of the United States to whom our winter "blizzards" are especially trying, it will be perhaps consoling to reflect that before the northwest wind can reach Bermuda, it must pass over many miles of ocean and over a wide expanse of the heated waters of the Gulf Stream, and the writer in the *Nautical Magazine* (the first one quoted by Dr. Hann) informs us that this wind "is at all seasons a pleasant one" in Bermuda, and that it does not seem to acquire moisture upon its way thither. Dr. Hann himself has further words of consolation for these haters of the northwest wind in the statement made by him, to the effect that "the prevailing direction of the wind" (at Bermuda) "is southwesterly; in winter more northerly; in summer and autumn, southerly." A third writer quoted by Dr. Hann (J. M. Jones) is authority for the statement that during the summer months the night temperature in Bermuda is cooler by only three or four degrees Fahrenheit than is the temperature at noon. He also bears witness to the debilitating effect of the Bermuda summer climate, but says that "it is not the continuous heat by day and by night, nor yet the frequent occurrence of calms at this season, which make the climate so debilitating, but rather it is the southwest wind which then prevails, and which saturates the atmosphere with moisture to such a degree as to make one feel as if he were in a vapor bath. Persons who have resided for many years in the West India Islands, under the refreshing influence of the 'dry trade-winds,' testify that the summer climate of the Bermudas gives the impression, to the feelings at least, of being much warmer than that of the West Indies, and that it has a more enervating effect upon them than anything which they have ever experienced further south."

Although, with the exception of the very damp and warm period, comprised chiefly within the two months of August and September, the degree of elevation attained by the thermometer in Bermuda may indicate a moderate summer temperature, and although the combined features of its climate may indeed render the place an agreeable residence for many persons during the warmer portion of the year, nevertheless, in view of its great humidity, the summer climate can hardly be considered desirable for, and is little likely to be sought by, invalids dwelling in the United States. To many such persons, on the other hand, its mildness and its comparative equability may well recommend the climate of these islands for residence during the whole or during a portion of the winter and spring seasons. There is little doubt that to all persons coming to Bermuda from the severely cold and very changeable winter weather of the Northern United States, the weather of the "Isles of Summer" would appear by comparison delighfully warm and very free from sudden changes of temperature; nevertheless, lest too great and too absolute a standard of equability

should be expected by such would-be refugees from our own inclement winter weather, it may be well to remind them that the Bermudas are extra- and not intra-tropical islands. Appletons' "Handbook of Winter Resorts," in describing the winter climate of Bermuda, tells us that "the mean temperature in winter is 60° F. and the thermometer rarely records 40° F.; but rain falls copiously during the winter months, and violent storms are frequent. At such times the variations of temperature are sudden and marked, and the air becomes surcharged with a penetrating moisture." As protection against the dampness, the writer in *Harper's Magazine*, quoted in this same "Handbook," advises invalids to use care in selecting for residence such houses as are properly provided with appliances for artificial heating. J. M. Jones (quoted by Hann) also speaks of the frequent occurrence of gales of wind during the winter season at Bermuda, and even alludes to a degree of cold sufficiently severe for the formation of hoar-frost and of thin ice, which visited the island upon one occasion (December 24, 1840). This formation of ice in Bermuda appears, however, to have occurred but once, and the cold weather which induced it was accompanied by a clear sky and a north wind. In other words, it seems to have been an instance of the partially successful crossing of the Gulf Stream by a "blizzard." How bitterly cold this wind must have been before reaching the Gulf Stream and before leaving the continent of North America it is painful to reflect.

Concerning the general healthfulness of the Bermudas the writer in the "Encyclopædia Britannica" speaks as follows: "The climate of the Bermudas has a reputation for unhealthiness which is hardly borne out, for the ordinary death-rate is only 22 per 1,000. Yellow fever and typhus, however, have on some occasions raged with extreme violence, and the former has appeared four times within the space of thirty years." The writer in *Harper's Magazine*, already several times alluded to, is disposed to attribute these visitations from yellow fever "rather to imperfect drainage and defective quarantine regulations than to any predisposing causes in the climate," and further remarks that at present "the enactment of strict quarantine laws, which are rigidly enforced upon all vessels, goes far toward preventing the introduction of epidemics from other places."

Lombard classes the Bermudas as "among the most healthful of the English colonies," and commends the climate for invalids, and especially for cases of pulmonary phthisis. Weber commends the climate for cases of laryngeal and bronchial catarrh, but says that it is less beneficial in cases of phthisis. By others the Bermudan climate has been declared to be serviceable to some cases of rheumatism, of asthma, and to certain forms of nervous disease; but for phthisical patients, excepting only some cases in the very earliest stages of the disease, the common opinion seems to be that Bermuda is not well suited, its climate being much too damp and too relaxing. A short trip to Bermuda during the spring months is doubtless most serviceable to such overworked dwellers in our northern cities as can support the sea voyage (three days from New York) without much discomfort.

Huntington Richards.

BETHESDA SPRING. *Location and Post-Office*, Waukesha, Waukesha County, Wis.

ACCESS.—By Chicago, Milwaukee & St. Paul, and Chicago & Northwestern Railways, to Waukesha, sixteen miles west of Milwaukee.

One pint contains (C. F. Chandler):

	Grains.
Sodium carbonate	0.109
Magnesium carbonate	0.918
Ferrous carbonate	0.004
Calcium carbonate	1.478
Sodium chloride	0.145
Potassium sulphate	0.057
Sodium sulphate	0.068
Sodium phosphate	trace
Alumina	0.015
Silica	0.092
Organic matter	0.248
Total	3.134

THERAPEUTICAL PROPERTIES.—This is a sparkling and agreeable water, and though devoid of any unusual mineral ingredient, it has a well-founded reputation as a very useful agent in establishing diuresis and promoting healthy nutrition. It is chiefly useful in congestive and inflammatory diseases of the abdominal and pelvic viscera, such as indigestion, albuminuria, cystitis, etc.

These springs are located in a valley famed for its beautiful scenery and diversified attractions. The climate is of a bracing character, with a mean temperature, in summer, of 68° F., and in winter of 20° F. The average rainfall is about thirty inches. Hotel accommodations are good and ample.

The village is a thriving place of about 4,000 inhabitants, with churches of different denominations and several first-rate schools. Besides the village, which, during the season, is gay and lively, and a park of thirty acres at the springs, there are numerous lakes, from six to ten miles distant. They are accessible by fine drives, and furnish good fishing and boating.

HISTORY.—Since 1868, when a well-known gentleman, suffering from diabetes mellitus, accidentally discovered the curative qualities of these waters for his malady, the reputation of the springs has steadily grown. *G. B. F.*

BETHLEHEM, N. H. The village of Bethlehem, situated in the northern portion of the State of New Hampshire (Grafton County), about twenty miles west of Mount Washington, has acquired considerable reputation as a summer health-resort, especially for persons suffering from hay fever. The population of the town, according to the United States Census of 1880, was 1,400. Its surroundings are attractive, affording opportunities for the making of pleasant excursions to the neighboring mountains. It commands a fine view of the principal peaks of the White Mountain range. It has a cool, dry, and healthful summer climate, lies at a considerable elevation (1,459 feet) above sea-level, and affords excellent hotel accommodations. The water-supply and drainage of the hotels are said to be good. Among the many attractive resorts which abound throughout the whole White Mountain district of New Hampshire, the so-called "Switzerland of America," this town of Bethlehem is selected for especial mention by the writer, chiefly because, up to the present time, it is the only one concerning the summer climate of which he is in possession of any reliable data. The brief table given below, and showing the temperature, relative humidity, and prevailing wind, at Bethlehem, during the two months of July and August and the first week of the month of September, was kindly furnished by Dr. W. H. Geddings, of Aiken, S. C., its figures being deduced from observations extending over a period of several years which were made by Dr. Geddings during his annual visit to this place.

An article from the pen of this gentleman concerning the summer climate of Bethlehem, which appeared originally in the columns of the Boston *Medical and Surgical Journal* (1879), and the greater portion of which has since been reprinted in a little pamphlet entitled, "Bethlehem as a Resort for Health and Pleasure" (a copy of which pamphlet was kindly furnished to the writer by Dr. Geddings), contains more detailed information respecting the Bethlehem summer climate, and gives a table showing the number of days during which an invalid may remain in the open air during the whole, or during a part of each day, etc. The doctor's observations of the weather, from this particular point of view, were made during the months of July and August, 1878 and 1879, and he sums up the result of his observations as follows: "Out of sixty-two days the invalid can with safety remain out of doors during the whole of fifty and during a portion of six, while out of the whole number of days in the two months there were only four and a half on which the weather was of such a nature as to necessitate his confinement within doors during the whole day. In preparing this table, in addition to rain, very cool and windy weather was taken into consideration." Dr. Geddings states, as the result of his observations, that the summer climate of Bethlehem "is cool, and consequently tonic,

Climate of Bethlehem, N. H.—Latitude 44° 16′, *Longitude* 71° 41′.—*Period of Observations: July, August, and first week of September,* 1878, 1879, 1881, 1882, *and* 1884—*Elevation of Place above the Sea Level,* 1,459 *feet—Name of Observer,* W. H. Geddings, M.D., *P. O. Address, Bethlehem, N. H., and Aiken, S. C.*

	A			B		C	D	E		F		K	R
	Mean temperature of months at the hours of			Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Mean relative humidity.*	Prevailing direction of wind.
	7 A.M. Degrees.	2 P.M. Degrees.	9 P.M. Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.	Per cent.	
July	65.46	73.63	65.58	70.49	65.27	84	57	90	80	57	52	63	S.W.
August	64.07	73.15	65.95	68.36	63.22	85	52	90	80	54	47	60	S.W.
September 1st to 7th.	64.85	73.66	66.48	69.68	65.33	78	56	80	76	60	54	60	S.W.
Season	....	....	....	68.12	65.39	....	....	....	....	....	....	61	S.W.

* The relative humidity observations are for only two years, 1879 and 1884, no observation having been made in the intermediate years.

in its character, liable, like all mountain climates, to sudden changes; but that, for all this, the daily range of temperature is remarkably small, that it is very dry, and that the prevailing winds are of a pleasant character."

Huntington Richards.

BETONY, WOOD (*Betoine*, Codex Med., leaves). *Stachys Betonica* Benth. (*Betonica officinalis* Linn.), Order, *Labiatæ*, is a perennial herb, thirty to sixty centimetres (one or two feet) high, with purple-red flowers, and long-stemmed, mostly radical leaves. These are from five to eight centimetres in length (two to three inches), oblong crenate, heart-shaped, at the base, and hairy. The plant is a native of Europe, growing in pastures and woods. The leaves, when fresh, have a faint, disagreeable odor—which mostly disappears upon drying—and a bitter astringent and nauseous taste.

Betony in former times had a high reputation for a variety of troubles; at present it is not in use. Dose of the dried leaves as a "nervine, expectorant, sudorific," etc., from one to three grammes (gr. xv. ad gr. xlv.). The root is said to be emetic.

Allied Plants.—Several other species of *Stachys* have similar unpleasant properties, and have been used. All are now neglected. For a notice of the order, see Peppermint.

Allied Drugs.—Horehound, Lycopus, Motherwort, and other bitter Labiates; Thoroughwort and other bitter *Compositæ*, besides many others. *W. P. Bolles.*

BIARRITZ.—A sea-coast town in the extreme southwestern portion of France, in the Department of the Basses Pyrénées, lying upon the shore of the Bay of Biscay, some five miles distant from Bayonne (Lat. 43° 27′ N., Long. 1° 37′ W.). At the present day Biarritz is well known as a fashionable seaside resort, possessing an excellent beach with a good surf, and having abundant and comfortable hotel accommodations and an agreeable climate. It is much resorted to by visitors from all parts of France and from other countries during the bathing season, which not only comprises the summer months, but also extends much later into the autumn than is the case with similar seaside stations lying farther to the north. Although, as we are told by Dr. Bennet ("Winter and Spring on the Shores of the Mediterranean," 5th edition, 1875, p. 606), the town of Biarritz "has long been resorted to by the inhabitants of Bayonne and of the Pyrenean district, in summer, for its excellent sea-bathing;" yet, as this author goes on to say, "it was all but unknown to fame until the Empress Eugenie brought it into notice by making it her marine autumnal residence." As an evidence of its present popularity we read in the "Encyclopædia Britannica" that "the permanent population of Biarritz, according to the census of 1871, was 3,164;" while, on the other hand, "the autumn visitors are estimated at from 12,000 to 15,000." The coast at Biarritz is decidedly rocky and very picturesque, being in this respect as different as possible from the low-lying and purely sandy shores of the Department of the Landes, which border the Bay of Biscay farther to the north. To the vast extent of sand-covered country constituting the greater portion of this Department (Landes), and comprising in all an area of some 3,700 square miles (Bennet, *op. cit.*), the climate of Biarritz is doubtless indebted for at least a part of that dryness and of that mildness in winter for which it is celebrated. The summer heat at Biarritz is tempered by the prevailing westerly winds, which blow from the Atlantic. The situation of the town, directly upon the shore of the ocean, is also another element in insuring to it a mild and a comparatively equable temperature during the winter months. Its climate at this season is very similar to that of Arcachon, which has already been described in preceding pages of this Handbook (see Arcahon). The reputation of Biarritz as a winter resort is of still more recent date than is its great popularity as a summer bathing station, and doubtless depends in a measure upon the latter. As explained by Dr. Bennet, the very extensive preparations for the entertainment of summer and autumn guests have a tendency to cheapen considerably the cost of living in Biarritz during the colder months which follow; and this cheapness of living is offered by the doctor as an inducement, and in many cases a most important inducement, to attract thither a class of invalids requiring a place of residence for the winter season, which offers the advantage of a mild and equable climate unaccompanied by the high, and too often exorbitant, cost of living which frequently prevails at such sanitaria. "It is impossible," says this author, "that a town situated on the boisterous Bay of Biscay can be equal in point of climate to the Riviera undercliff, or to the east coast of Spain, in cases of severe disease in which the best climate that can be found is required. But still there must be many cases in which the sunshine and mild temperature of the southwestern coast of France may be sufficient. Moreover, the question of expense is often, unfortunately, a paramount consideration." Another class of persons to whom Dr. Bennet proposes a sojourn at Biarritz (and in this instance a sojourn not during the winter, but during the bathing season) are such residents in the British Isles as have been for various reasons unable to resort to the seaside stations of their own country during the months of July and August. "Those who cannot resort to our own coasts in July and August, and to whom a mild or warm temperature is essential, have thus the opportunity of still enjoying at Biarritz summer sea-bathing at a time when with us both the sea-water and the external atmosphere are becoming chilly." (The time referred to by the doctor in the above-quoted passage is the autumn season, the two months of September and October, of which he had just been speaking.)

Full and detailed statistics for the climate of Biarritz the writer is unable to present. The following statements, both general and particular, respecting the climatic features of the place have been culled from the pages of various authors, and are herewith presented to the reader.

The mean winter temperature at Biarritz is given by Weber (Ziemssen's "Handbuch der Allgemeinen Therapie") as 6° to 8° C. (=42.8° to 46.4° F.). The "Dictionnaire Usuel des Sciences Médicales" gives the figures of the three months of January, February, and March for a single year (1868) as follows: January, 40.26° F.; February, 40.91° F.; March, 44.62° F. The mean of these would be, of course, 41.93° F., a decidedly lower figure than that just given on Weber's authority, and indicating for the winter of 1868 a temperature probably below the normal, especially if we take into account that this figure (41.93° F.) is the mean for January, February, and March, and not for the three months of winter, viz., January, February, and December. The average spring temperature is placed by Weber at from 11° to 12° C. (=51.8° to 53.6° F.); that of the summer season at about 64.4° F. Dr. Bennet refers to observations of the temperature made at Biarritz by the Rev. Mr. Crow during the winter of 1862. The average of this gentleman's observations "made at 8 A.M. on a north wall" during January of that year was about 45° F.; the highest temperature being 62° F., the lowest 30° F. "In February there was some very cold weather. During seven days the highest temperature was 34° F. (at 8 A.M.), the lowest 24° F. With the exception of that week, the weather was glorious, the thermometer after January varying from 48° to 62° F." (Bennet, *op. cit.*, page 612). Lombard speaks of the climate of Biarritz as being a moist one, and Weber gives its relative humidity as about 80.0 per cent. This is no more than we should naturally expect in a place lying so directly upon the shore of the ocean, and so exposed to sea-winds. "Biarritz," says Dr. J. Burney Yeo, "lies exposed to all the fury of the Atlantic winds, and has no protection like the pine forest of Arcachon" ("Health Resorts and their Uses," London, 1882, p. 262). "The wind, when it blows from the southwest or northwest, is often furious" (Bennet, *op. cit.*). The annual rainfall is given by Weber as 49.21 inches. Concerning the rainfall during the winter season, we read in Dr. Bennet's book that "Dr. Chapman, an English physician, who long practised at Biarritz, states that the average rainfall during three years for the seven winter months, from the beginning of October to the end of April, was 25.81 inches on seventy-six days.

The sky at Biarritz is usually clear ("Dict. Us. des Sc. Méd.").

Concerning the class of invalids likely to be benefited by a stay at Biarritz during the winter months, it may be said that in the main they would be such cases as would be improved, or it may be even cured, by residence at the not far distant resort of Arcachon, to which reference has already been made in this article. But it must be borne in mind that Arcachon, lying as it does some miles back from the Atlantic coast, surrounded by extensive sand-dunes, and sheltered in some measure from the severity of sea-winds by pine forests, is necessarily a somewhat dryer and a more protected spot than is Biarritz. Dr. J. Burney Yeo declares (*op. cit.*, page 262) that the winter climate of Biarritz is "more bracing and less mild" than is that of Arcachon, and "is by no means so well suited to cases of chest disease." It is, however, he adds, "well suited to some forms of nervous exhaustion and irritability." Dr. Bennet speaks pretty much to the same effect concerning the climatotherapy of Biarritz. He considers the place far less suited to consumptive invalids than the dryer, milder, and more sheltered resorts lying along the Genoese Riviera and upon the Mediterranean coast of Spain, but regards it as probably quite as well, or even better, adapted for such cases than are the famous resorts of the Isle of Wight and of other parts of the English south coast.

In conclusion, it may be remarked that over and above its excellent hotel accommodations, the neighborhood of Biarritz abounds in comfortable and attractive villas, often surrounded by gardens, and situated at various points close to, or even directly upon, its picturesquely rocky shores.

Huntington Richards.

BIBIRU BARK (*Nectandræ Cortex*, Br. Ph.; Bebeeru, Greenheart, etc.). The bark of *Nectandra Rhodiæi* Schomburg, Order, *Laurineæ*; a fine forest tree, with a tall, straight stem, attaining a height of twenty-five or thirty metres (75 to 90 feet). It has thick, evergreen, coriaceous, oval leaves, and small axillary clusters of white flowers. The fruit is large, one-seeded.

The Greenheart tree is a native of British Guiana, where it is highly prized as a source of the best ship timber. It was proposed as a febrifuge, and its alkaloid pointed out by Dr. Rodie, of Demerara, about fifty years ago.

The bark is imported in large, long, heavy, flat pieces, from one-half to one centimetre in thickness (one-fifth to two-fifths inch). It is hard and brittle, breaking with a coarse, fibrous fracture; it is grayish-brown externally, cinnamon-brown and striated upon its inner surface. Its cells are seen under the microscope to be thickened, those of the liber curiously dentated. It has a strong bitter taste, *without aroma*—an unusual thing for any member of the order *Laurineæ*.

The bitterness of this substance is due principally to the alkaloid *buxine* (bibirine, bebeerine (not berberine), nectandrine, etc.), which it contains to the extent of one-half or one per cent. It also contains one or two other alkaloids, and tannin. The wood, which is also bitter, contains a similar base to that in the bark. The seeds are sometimes made use of as a source of starch. The impure buxine of Nectandra is an article of commerce, and generally known as bebeerine. It is a gray or brownish amorphous, bitter substance, permanent in the air, and very insoluble in water ($\frac{1}{6000}$). One or two of its salts, especially the sulphate and hydrochlorate, are also to be had, and should be preferred for administration on account of their free solubility.

The bark, and especially the alkaloid and its salts, have been offered, and to some extent employed as a febrifuge and antiperiodic; that is, as a substitute for quinine, but in reasonable doses they fall far short of that medicine for the purpose. They are, however, good simple bitter tonics (the bark is astringent as well), and fair duplicates of those named below. Doses: a useful dose of the bark would be large and disagreeable. Buxine or its salts may be given, as a tonic, in pills or solution, up to two to four decigrammes (0.2 to 0.4 = gr. iij. ad vj.), as a febrifuge, up to one or two grammes (gr. xv. ad xxx.).

ALLIED PLANTS.—See CINNAMON.

ALLIED DRUGS.—For a list of buxine-containing bitters, see BOX. As a tonic it may be compared with the berberine group—see BARBERRY. Also with the pure bitters—see GENTIAN, etc. It is scarcely to be compared to Cinchona as an antiperiodic.

W. P. Bolles.

BIG BONE SPRINGS. *Location and Post-Office*, Big Bone Springs, Boone County, Kentucky.

ACCESS.—By Louisville, Cincinnati & Lexington Division of the Louisville & Nashville Railroad, to Walton, thence by stage to Springs.

ANALYSIS.—"Geology of Kentucky" states the constituents of these waters to be: chloride of sodium, sulphate of magnesia, sulphate of soda, sulphate of alumina, bicarbonate of lime, bicarbonate of magnesia, carbonate of soda, and sulphuretted hydrogen gas.

THERAPEUTIC PROPERTIES.—This is an alkaline-sulphur water of local reputation. In the absence of a quantitative analysis, it is impossible to say more.

G. B. F.

BILE. PROPERTIES AND CHEMICAL BEHAVIOR OF BILE.—The bile of man, as obtained by O. Jacobsen from a fistula, was clear, greenish-brown, with a tinge of yellow, of neutral reaction, and specific gravity of 1.01. In the newly-born it is more viscid than later. The smell in man is insipid; in the ox, almost aromatic. The taste of bile is always strongly bitter; its reaction neutral or alkaline. It may be diluted with water without turbidity, and when shaken foams.

The salts of the bile-acids are sometimes known as "Crys-

tallized Gall." Acetic acid precipitates mucin from bile, and strong mineral acids the resinous bile-acids themselves, glycocholic being the major constituent. When bile is shaken with chloroform, carbon bisulphide, benzol, etc., yellow and brown coloring matters pass over into the solvent.

THE PUTREFACTION OF BILE.—The reaction of bile changes from neutral to alkaline under putrefaction, which with suitable temperature easily arises. It gets stinking and vibrios are abundant. Later the reaction becomes acid, which for a time increases, and taurin appears, also sodium sulphate; while in fresh bile sulphuric acid is scarcely demonstrable. The products of the putrefaction of bile are: carbonic acid, sulphurous and sulphuric acids; volatile and non-volatile fatty acids; earthy phosphates; ammonia, and trimethylamin.

CONSTITUENTS OF BILE.—The bile is distinguished from all animal fluids by its distinctly recognizable and demonstrable chemical properties; its constituents having each a distinct chemical individuality. Normal bile contains: bile acids, pigments, fats, soaps (alkaline palmitates, stearates, oleates), cholesterin, lecithin, mucin, traces of urea, the usual inorganic salts, and carbon dioxide.

Cholin or *Neurin* is to be considered as a decomposition product of lecithin, and mucin as the product of the secretion of the glands of the gall-bladder.

The Bile-acids do not occur free, but combined with potassium, and especially sodium. They are glycocholic and taurocholic, or tauringallic, which, upon boiling with an acid, split off in the one case glycocoll or glycin, and in the other taurin.

$$\underset{\text{Glycocholic}}{C_{26}H_{43}NO_6} + H_2O = \underset{\text{Chololic}}{C_{24}H_{40}O_5} + \underset{\text{Glycin.}}{C_2H_5NO_2}.$$

$$\underset{\text{Taurocholic}}{C_{26}H_{45}NSO_7} + H_2O = C_{24}H_{40}O_5 + \underset{\text{Taurin.}}{C_2H_7NSO_3}.$$

RECOGNITION OF THE BILE-ACIDS.—This is best effected by Pettenkofer's reaction. Pour a portion of the fluid to be tested (after the removal of albumen) into a porcelain dish, add carefully two-thirds of its volume of concentrated sulphuric acid, and then a few drops of a ten per cent. solution of cane-sugar, upon which a fine, dark purple-red color appears. The addition of sulphuric acid is to be made in such a manner that the temperature will not rise above 70° C. Grape-sugar or fruit-sugar may be used instead of cane-sugar. The color is lasting. The test is not infallible, for many other substances give it—among these albuminous bodies.

All of the bile-acids and their sodium salts, with the exception of hyoglycocholic, turn the plane of polarization to the right.

Glycocholic Acid, $C_{26}H_{43}NO_6$. This acid occurs abundantly in combination with sodium in ox-gall, but less so in the bile of the carnivora. It may be obtained in fine white needles and star-shaped groups of needles. Their taste is at first sweetish, but afterward very bitter. They redden litmus, and at 100° C. melt to colorless glycocholonic acid. This acid is but slightly soluble in cold, more so in hot, water; easily in alcohol and acetic acid; with difficulty in ether.

Polarization: acid = + 29.0°
sodium salt = + 25.7° (Hoppe-Seyler).

Glycocholate of Sodium, $C_{26}H_{42}NaNO_6$, is made by dissolving glycocholic acid in sodium carbonate. It is very soluble in water. The salts of potassium, ammonia, barium, lead, and silver are also known. By decomposition glycocholic acid yields glycocoll or glycin (amido-acetic acid), $NH_2—CH_2—COOH$, which may be obtained in colorless crystals (prisms).

Paraglycocholic Acid (paracholic), $C_{26}H_{43}NO_6$, is an isomer of glycocholic acid, discovered by Strecker in ox-gall, but is distinguished by its insolubility in boiling water.

Glycocholonic Acid (cholonic of Mulder and Strecker), $C_{26}H_{41}NO_5$, is glycocholic minus one molecule of H_2O. It is insoluble in cold water and ether.

Chologlycocholic Acid, $C_{26}H_{42}O_7$, and *Glycodyslisin Acid*, $C_{26}H_{39}NO_4$, need only be mentioned.

Cholic Acid, $C_{24}H_{40}O_5$. This acid is not found in fresh bile, but in the alimentary canal as a result of digestion, and in putrefying bile as a result of chemical decomposition. It may also be obtained from the native bile-acids by treatment with mineral acids, alkalis, or the action of ferments.

It occurs in both an amorphous and a crystalline form, which show different degrees of solubility. It forms salts with alkalis, barium, lead, silver, iron, copper, mercury, etc.

When water-free its polarization is + 50°; with 2½ molecules of water, + 35°. The anhydrides of cholic acid are dyslysin and choloidic acid.

Taurocholic Acid, $C_{26}H_{45}NSO_7$ (choleic acid of Strecker and Demarcay). It is most abundant in the bile of the carnivora and of fishes. It may be obtained in the form of fine glistening needles, which, however, soon deliquesce in the air. This acid is much less stable than glycocholic. It is soluble in water and alcohol, strongly acid, and decomposed even by boiling. It also turns the plane of polarization to the right, but not so strongly as glycocholic acid. It forms numerous salts, of which the principal is the taurocholate of potash, $C_{26}H_{44}KNSO_7$, found in the bile of many fishes, often almost exclusively; the taurocholate of sodium, $C_{26}H_{44}NaHSO_7$, is easily got from dog's bile. The salts of barium and lead are also known.

Taurin, $C_2H_7NSO_3$, may be obtained colorless and perfectly pure in brilliant columns of the monoclinic system. Its reaction is neutral; it has no marked taste; remains unaltered in the air, and may be heated without change up to 240° C. It is soluble in water, especially warm water, but not in strong spirit or ether. It is isomeric with amidoisæthionic acid

$$\begin{array}{l} CH_2NH_2 \\ | \\ CH_2SO_2OH. \end{array}$$

The exact destiny of taurin in the animal economy is not known, but there is good reason to believe that it is absorbed from the alimentary canal and profoundly changed.

Cholesterin, $C_{26}H_{44}O$ and $C_{26}H_{44}O$, H_2O. This substance is very widely distributed in the animal kingdom, and also occurs in plants. It may be obtained in thin plates, colorless, glistening like mother-of-pearl, and of the monoclinic system; also in leaves and scales. When crystallized from chloroform or petroleum instead of ether, as above, it appears in glistening needles. Cholesterin is soluble in acetic ether, carbon bisulphide, wood-spirit, glacial acetic acid, benzol, toluol, petroleum, oil of turpentine; but is insoluble in water and dilute acids and alkalis; somewhat soluble in soap solutions; in watery solutions of the bile acids and their salts; also in fats and oils; which latter facts are of great importance in the animal economy.

Its polarization is − 32° (Hoppe-Seyler). Its molecular constitution is unknown. It occurs in many pathological fluids, gall-stones, etc., to which reference will be made elsewhere.

THE BILE-COLORING MATTERS.—*Bilirubin* (biliphæin, cholepyrrhin, bilifuloin ?), $C_{16}H_{18}N_2O_3$. This pigment occurs in the bile of man, the hog, the dog, etc. It occurs in a crystalline form in old blood extravasations, etc. It doubtless composes much of the so-called hæmatoidin: while it constitutes in part the coloring matter of the blood-serum, at least in the horse (Hammarsten). It is very abundant in certain kinds of gall-stones, united with lime (Bramson), especially those from oxen and hogs. Bilirubin is an amorphous, orange powder; when in crystalline form it is darker. It is soluble in chloroform, less so in carbon bisulphide, slightly in benzol, petroleum, glacial acetic acid, alcohol, ether, turpentine oil; also with ease in alkalis, alk. carbonate, and ammonia. It has no characteristic spectrum.

Biliverdin, $C_{16}H_{18}N_2O_4$, occurs in the bile of oxen and other herbivora, of the frog, and many cold-blooded animals. It is to be considered as an oxidation product of

bilirubin. It also occurs in the placenta, and in the contents of the alimentary canal; but only in traces in gall-stones. It occurs as a dark-brown amorphous powder, also in rhombic plates, and is insoluble in water, ether, pure chloroform, carbon bisulphide, benzol; easily soluble in proof-spirit, wood-spirit, glacial acetic acid, and in chloroform. Like bilirubin, its alkaline solution is changed by nitric acid, undergoing a series of oxidations represented by a succession of colors—blue, violet, red, and, finally, yellow. It has no characteristic spectrum.

Bilifuscin occurs often in connection with bilirubin, but its genetic relation to the latter is not known.

Biliprasin and *Bilihumin* have been found in gall-stones.

Bilirubin and Biliverdin form with nascent hydrogen hydrobilirubin; with nitric or nitrous acid a series of oxidation products, which are observed in the application of Gmelin's test. A series of colored bodies are formed by the action of bromine which are not oxidation products, but combinations with bromine.

Hydrobilirubin, $C_{32}H_{40}N_4O_7$. Jaffé found a coloring matter in febrile urine which he called Urobilin; this is probably identical with hydrobilirubin. Maly produced it artificially from bilirubin. This pigment gives a dark band in the spectrum between b and H. It arises in the alimentary canal, probably by the action of nascent hydrogen on bilirubin; it can certainly be demonstrated in the fæces. Hoppe-Seyler obtained a similar, if not an identical, pigment from blood, which suggests some relation between the blood and bile-pigment.

Gmelin's Test.—When a drop of crude nitric acid, which mostly contains some nitrous acid, is added to a fluid containing bile, upon a porcelain surface, a series of colors appear in rapid and tolerably uniform succession. Of these, the essential ones are green and violet, which should be more permanent than the others. The explanation of this reaction has already been given above. The oxidation products are: cholecyanin or bilicyanin, corresponding to the blue ring; bilipurpurin, to the dark-red; and choletelin to the yellow. The essential green is, of course, biliverdin.

COMPOSITION OF BILE.—*Of Man.*—The following table presents at a glance the composition of bile as the results of quantitative analyses:

In 1,000 parts Bile.	FRERICHS.		GORUP-BESANEZ.			
	Man of 18 killed by sudden violence.	Man of 22 killed by a wound.	Man of 49 beheaded.	Woman of 29 beheaded.	Man of 68 killed by sudden violence.	A boy of 12 killed by a wound.
Water	860.0	859.2	822.7	898.1	908.7	828.1
Solids	140.0	140.8	177.3	101.9	91.3	171.9
Alkaline bile-salts	102.2	91.4	107.9	56.5	....	....
Fat	3.2	9.2	} 47.3	30.9	....	....
Cholesterin	1.6	2.6			....	....
Mucus and coloring matters	26.6	29.8	22.1	14.5	17.6	23.9
Mineral	6.5	7.7	10.8	6.3		
Sod. chloride	2.5	2.0	....	....	....	....
Sod. phosph.	2.0	2.5	....	....	....	....
Earthy phosph.	1.8	2.8	....	....	....	....
Calc. sulph.	0.2	0.4	....	....	....	....
Iron oxide	Trace.	Trace.	....	....	....	....

The bile-acids of the bile of man are very imperfectly known, but glycocoll and taurin are united with them, and the presence of bilirubin and hydrobilirubin have also been demonstrated in the bile of man.

GALL-STONES may be divided as follows:

1. Cholesterin stones, white or yellow in color, and composed almost wholly of cholesterin.
2. Bilirubin lime-stones, from yellowish red to brown; non-crystalline; easily pulverized, and abounding in bilirubin.
3. Dark green, or black stones, small, often of metallic appearance; without cholesterin; cholesterin and bilirubin.
4. Inorganic, concentric in structure, made up of calcium carbonate, or earthy phosphates.

ACTION OF BILE ON THE FOOD-STUFFS OF THE CHYLE OF THE STOMACH, AND THEIR PHYSIOLOGICAL SIGNIFICANCE.—1. *Action on Albuminous Bodies.*—Bile seems to have no digestive power whatever over these, for when all the bile is drained away through a fistula, the albuminous matters are as fully digested as before.

2. *On Carbohydrates*, the bile has also not the slightest action.

3. *On Fats* it does exercise a slight solvent action; a slight emulsifying power, joining with fatty acid soaps; it dissolves solid soaps, which may facilitate in turn the emulsion of fats. The passage of fats through membranes is more rapid when they are kept moistened with bile or a solution of bile salts.

4. *On the Chyme of the Stomach.*—In so far as the bile being neutral or alkaline tends to neutralize the acidity of the gastric juice, it retards digestion. But if bile is added to a fluid in which gastric digestion is proceeding, a precipitate occurs, consisting of parapeptone, peptone, and bile-salts; these, however, may be redissolved in an excess of bile. This precipitation is favorable to digestion, as will be seen later (see Digestive Juices).

THE ANTISEPTIC ACTION OF BILE.—When the bile is not poured into the alimentary canal, decomposition, to which there is a natural tendency, proceeds more rapidly; gases appear abundantly, and decomposition products may be detected in the breath; this condition may lead to marasmus and early death, without local disease. Bile itself has a tolerably ready tendency to decomposition, but not nearly to the same extent as pancreatic secretion (Maly: "Chemie der Galle," in Hermann's "Handbuch der Physiologie"). *T. Wesley Mills.*

BIOLOGY. Everyone knows, from personal observation and experience, that all objects in Nature may be arranged in two great groups, viz., living things and lifeless things. Moreover, it is the universal testimony of observation and reflection that the differences between living matter and lifeless matter are so great as to be fairly called enormous. Nevertheless, it is not generally understood that the various branches of human knowledge may be classified according as they pertain to the one or the other of these great groups; nor that at this point of view a new science—biology—has arisen, which is so ambitious as to claim for itself the whole field of living matter. The classification to which reference is made turns upon the differences which have been mentioned, and which will be discussed later, and regards all sciences as either *biological* (βιος, life, λογος, a discourse) or *abiological*. For example, zoölogy, botany, anatomy, physiology, pathology and the other medical sciences, sociology, psychology, history, etc., are sciences pertaining to living things, and therefore biological; while mathematics, astronomy, geology, mineralogy, etc., are obviously abiological. Still others, as physics and chemistry, are concerned now with living and now with lifeless matter, and are therefore members of both groups. Such sciences deal not so much with the qualifying property, viz.: life, as with the common substance-matter which is found, of course, in both groups.

The point of view which has been thus far occupied would be of but little importance, however, if its only result were a new, and it must be admitted, a somewhat imperfect, taxonomy. It is chiefly significant because it is the starting-point of a new and aspiring science, biology.

Biology, as the word implies, is *life-science;* but because life is never found apart from living matter, biology becomes practically the science of living matter, and hence of living things—both plants and animals. It is necessary, so great is the misapprehension upon this point, to insist that biology is concerned with every detail of every living thing, whether plant or animal, whether high in the scale like mammals and seed-plants, or lowly forms like protozoa and protophytes. The structure, the habits, the forms, the functions, the origin, and the fate of living matter in health or in disease, wherever found, constitute the domain of biology.

Historically speaking, biology is a synthetic science, having sprung from the union of zoölogy and botany, under which familiar forms it has long been studied. But although the term had been employed by Treviranus and others previous to 1850, it is only within a few years that it has been widely adopted as the title of an experimental science, including both the older sciences of zoölogy and botany. As distinguished and developed from these branches of knowledge, biology is characterized by its breadth, since it includes them both, and especially by the fact that biologists insist upon the essential and substantial identity of living matter in composition, structure, and function, whether found in plants or in animals; hence, also, upon a close relationship between these great groups of living things. In other words, biologists maintain that plants and animals have substantially the same chemical composition, are constructed in essentially the same way, and that they fulfil in a fundamentally identical manner the various functions of respiration, nutrition, digestion, assimilation, and reproduction. These facts once established, biologists proceed to draw the conclusion that so remarkable an identity or similarity argues some definite relationship, and to offer the hypothesis that the resemblances are, as a rule, fundamental and ancestral, while the differences are, as a rule, secondary and acquired. The similarity between plants and animals had by no means escaped the earlier naturalists, but it failed to receive its due weight, largely, no doubt, owing to the prevalent ideas of the origin of species by special creation. With the fall of this doctrine, and the rise of the theory of evolution, the attention which had been unduly fixed upon the differences between species was turned toward their resemblances; and when this was done room was speedily found for a new science, viz., biology.

Living Matter or Protoplasm. Life.—Certain fundamental properties of living matter common to plants and animals, but not observed in lifeless matter, must now be pointed out. Biologists are indebted to Huxley ("Encyclopædia Britannica," ninth edition, vol. iii., p. 679, article "Biology"), for the clearest and best statement which exists regarding these distinctive properties, They are important enough to be assigned the first rank among the fundamental principles of the science, and stand as follows:

"The distinctive properties of living matter are:

"1. *Its chemical composition.* Containing, as it invariably does, one or more forms of a complex compound of carbon, hydrogen, oxygen, and nitrogen, the so-called protein (which has never yet been obtained except as a product of living bodies), united with a large proportion of water, and forming the chief constituent of a substance, which, in its primary unmodified state, is known as protoplasm.

"2. *Its universal disintegration and waste by oxidation: and its concomitant reintegration by the intussusception of new matter.* A process of waste resulting from the decomposition of the molecules of the protoplasm, in virtue of which they break up into more highly oxidated products, which cease to form any part of the living body, is a constant concomitant of life. There is reason to believe that carbonic acid is always one of these waste products, while the others contain the remainder of the carbon, the nitrogen, the hydrogen, and the other elements which may enter into the composition of the protoplasm.

"The new matter taken in to make good this constant loss is either a ready-formed protoplasmic material, supplied by some other living being, or it consists of the elements of protoplasm united together in simpler combinations, which consequently have to be built up into protoplasm by the agency of the living matter itself. In either case, the addition of molecules to those which already existed takes place, not at the surface of the living mass, but by interposition between the existing molecules of the latter. If the process of disintegration and reconstruction which characterize life balance one another, the size of the mass of living matter remains stationary, while, if the reconstructive process is the more rapid, the living body *grows*. But the increase of size which constitutes growth is the result of a process of molecular intussusception, and therefore differs altogether from the process of growth by accretion, which may be observed in crystals, and is effected purely by the external addition of new matter; so that, in the well-known aphorism of Linnæus, the word 'grow,' as applied to stones, signifies a wholly different process from what is called 'growth' in plants and animals.

"3. *Its tendency to undergo cyclical changes.* In the ordinary course of nature, all living matter proceeds from pre-existing living matter, a portion of the latter being detached and acquiring an independent existence. The new form takes on the characters of that from which it arose; exhibits the same power of propagating itself by means of an offshoot; and sooner or later, like its predecessor, ceases to live, and is resolved into more highly oxidated compounds of its elements.

"Thus an individual living body is not only constantly changing its substance, but its size and form are undergoing continual modifications, the end of which is the death and decay of that individual; the continuation of the kind being secured by the detachment of portions which tend to run through the same cycle of forms as the parent. No forms of matter which are either not living, or have not been derived from living matter, exhibit these three properties, nor any approach to the remarkable phenomena defined under the second and third heads."

The peculiar properties of living matter thus described some years ago by Huxley have never since been better stated. Nor has the progress of science made any considerable changes in these fundamental principles needful. No link of connection between the living and the lifeless world has yet been found; and the extended study of living matter tends rather to emphasize the differences between them than to suggest that lifeless matter is ever changed to living matter except by the agency of preexistent life. The above quotation has been introduced at this point simply to show how definite and how legitimate is the field that biology occupies. Biologists have, obviously, at present, more than enough to do in their own peculiar sphere. Nevertheless, they view with profound concern the work of chemists and physicists upon matter—the basal fabric of the living not less than of the lifeless world. For the solution of the final problem—life itself—if, indeed, it shall ever be solved, more knowledge of elemental matter and more control over it will doubtless be required. At present life itself cannot be comprehended, still less defined. Apart from the phenomena of consciousness, and taking a purely physical point of view, it appears to be a state or a condition into which certain elements of lifeless matter may pass under the influence of pre-existing life, and in which, combined, they sojourn for a time, exhibiting peculiar powers. These powers constitute vitality. The condition is the living condition. Once out of it, matter is as truly lifeless again as is the copper wire of an electric circuit devoid of electric currents, after its connection with the battery is broken.

(See Matter, Living and Lifeless.)

Fundamental Principles of Biology.—Among the innumerable facts which pertain to biology we may select several which are of so fundamental and so general a character as to be worthy of special mention.

1. *Living matter, whether animal or vegetal, is clearly distinguishable from lifeless matter by* (a) *its morphology and* (b) *its physiology.*

For example, a single morphological feature—its peculiar chemical composition (vide supra)—serves to separate living from lifeless matter; while among distinctive physiological features we need instance only the peculiarities pointed out above by Huxley, viz., the habits of oxidation, intussusception, and cyclical change.

2. *All living things, whether animal or vegetal, are, broadly speaking, morphologically alike.*

This fact was slow in coming to the light. Living matter is universally admitted to occur in masses commonly described as "living organisms." These usually exhibit definite "organs" or parts, and these organs are plainly

not homogeneous, but, in the higher forms at any rate, resolvable into "tissues." Nevertheless, so striking are the visible differences between the higher plants and animals, that the less obvious likenesses of structure were but slowly recognized. Indeed, the microscope was indispensable in order to prové that in all these cases the tissues are never homogeneous, but, on the contrary, composed of distinct units called "cells." It is to-day possible to go still further, and to assert that even the cells are not homogeneous, but that they differ greatly, though identical in this: that in every cell there is more or less of a complex substance independently discovered in plant-cells, where it was called *protoplasm*, and in animal-cells, where it was called *sarcode*. At present this substance is considered to be essentially the same, wherever found, and is known as *protoplasm*.

In a word, it may be said that living matter occurs in masses commonly described as living organisms; these are composed of various parts, which are often so developed as to constitute organs and tissues; the organisms themselves being always composed of one or more cells, and the cells consisting essentially of protoplasm. All living matter is, therefore, essentially *protoplasm* in one form or another. But protoplasm never fails to contain protein, a definite chemical compound made up of the well-known elements, carbon, hydrogen, oxygen, nitrogen, and sulphur.

Hence it appears that biology is justified in claiming that all living matter is morphologically alike.

3. *All living things, whether vegetal or animal, are, broadly speaking, physiologically alike.*

Space will permit but a partial elucidation of this sweeping proposition. Two functions have already been discussed in the quotation from Huxley, viz.: first, universal disintegration of living matter by oxidation, and its reintegration by intussusception, giving rise to the wonderful phenomena of growth and repair, and, second, the universal tendency to cyclical change (reproduction). So also in respect to alimentation (the feeding function); circulation (the distribution of food to the organic units of the mass, and the collection of waste matters); excretion (the process of elimination of the effete matters); in all these cases living matter, when carefully and broadly considered, will be found to be essentially the same in its actions.

Biologists further maintain, in view of the foregoing principles, that the resemblances between living things are evidently greater than the differences between them, and more fundamental. That, therefore, the likeness is to be interpreted as primary, while the difference is secondary only; and they adopt provisionally the theory of descent and relationship through a common ancestry, as affording the best explanation of the likenesses between living things; while the familiar facts of variation, selection, and inheritance sufficiently explain the differences.

In this necessarily brief sketch of biology it is impossible to go further. Enough has been said to show the scope of the subject, and to give a passing glimpse into its wide territory. It must suffice, in conclusion, to give an idea of the modern arrangement of the subdivisions of biology.

THE BIOLOGICAL SCIENCES.—The classification of the biological sciences, commonly adopted, does not include all those which fall under the strict definition. History and some of the medical sciences, for example, are not yet generally recognized as really biological. This is to be deplored, especially in the latter case, as the medical sciences are so closely related to biology that benefits could not fail to arise from a recognition of the mutual relationship. From a list which includes already anatomy, histology, embryology, physiology, psychology, and sociology, there is no good reason for excluding, for instance, pathology, particularly since the germ theory of disease has assumed so important proportions.

General Biology is now widely studied as an introduction to the subject, and with a view to defending and extending the fundamental principles.

(Consult Huxley and Martin's "Practical Biology," New York, Macmillan & Co.; and Herbert Spencer's "Principles of Biology," New York, D. Appleton & Co.)

The relations of the acknowledged daughter-sciences are shown in the annexed scheme, to which brief, and therefore somewhat imperfect definitions have been added. (For detailed accounts of these sciences, see Zoölogy, Botany, Physiology, etc.)

- BIOLOGY. The science of life, *i. e.*, of living matter or living things.
  - MORPHOLOGY. The science of form; and including the composition and structure of living things.
    - *Anatomy.* The science of the gross arrangement of the parts.
    - *Histology.* Microscopic anatomy.
    - *Taxonomy.* The classification of living things.
    - *Embryology.* The science of the development of living things from the parent, especially in the earlier stages.
    - *Distribution.* The science of the disposition of living matter in space and time.
  - PHYSIOLOGY. The science of function, *i.e.*, of the actions, habits, and workings of living things in the most general sense, *e. g.*, the interaction of living matter and its environment.
    - *Physiology.* The special study of the functions of the individual in health and in disease: hence including *Pathology*.
    - *Psychology.* The science of mind.
    - *Sociology.* The study of the mutual relations of aggregates of living things.
- BOTANY. The science of vegetal living matter.
- ZOÖLOGY. The science of animal living matter.

William T. Sedgwick.

BIOPLASSON, a term introduced by Elsberg for the protoplasm. In consequence of the observation of the intercellular bridges by which the protoplasm of adjacent cells is in many tissues connected, Heitzmann has denied the existence of cells and asserted that the body consists of a network of protoplasm. Elsberg has adopted this strange theory and introduces bioplasson for protoplasm, a term which it is necessary to note only because it is used by a small circle of American writers. That Heitzmann's theory is erroneous, on account of its evident exaggeration, hardly needs demonstration. That fine protoplasmatic bands connect the adjacent cells of certain tissues, both in plants and animals, is now well established; but this does not in any way invalidate the cell doctrine. Even if it were true, which it is not, that, as Heitzmann apparently claims, all tissues consist of a network, this would not do away with cells as the unit of organization. The fatal objection to Heitzmann's view, however, is the fact that the union of cells is secondary, for during the segmentation of the ovum the cells are completely separated, and the connection between them does not exist until considerably later in the course of development. What Heitzmann considers as primary is, therefore, secondary; his theory has been almost unanimously rejected by histologists.

LITERATURE.

Elsberg: Notice of the Bioplasson Doctrine. Trans. Amer. Med. Assoc., 1875.

Heitzmann: Microscopical Morphology. 8vo. New York, 1883. (Presents Heitzmann's theories in extenso, but displays a strange disregard of contemporary research.)

Charles S. Minot.

BIRCHDALE SPRINGS. *Location and Post-Office,* Concord, Concord County, N. H.

ACCESS.—By the various railroads running to Concord. The springs are about four miles distant.

There are four springs, only one of which, "The Concord," has been analyzed.

ANALYSIS (C. F. Chandler).—One pint contains:

	Grain.
Carbonate of soda	0.016
Carbonate of magnesia	0.063
Carbonate of iron	0.034
Carbonate of lime	0.182
Chloride of sodium	0.047
Sulphate of potassa	0.008
Sulphate of soda	0.032
Phosphate of soda	0.001
Alumina	0.014
Silica	0.115
Organic matter	0.084
	0.596

THERAPEUTIC PROPERTIES.—The analysis shows this to be a mild chalybeate water. *G. B. F.*

BIRTHS, STATISTICS OF. The official statistics of births in the United States are very much less complete than in England or the continental countries of Europe. While in England full information can be obtained from the annual report of the Registrar-General, in this country one is dependent on the irregular and somewhat scattered reports of State and City bureaus of vital statistics.

The figures in the following tables refer to the number of births actually reported, which number falls somewhat short of the reality.

The number of still-births reported is very much below the actual number, accurate records of still-births being very uncommon.

STATISTICS OF THE ANNUAL BIRTH-RATE.

UNITED STATES, IN DIFFERENT STATES.

	For the year ending	Total number of births.	Ratio to 1,000 of population.
Connecticut	Nov. 30, 1883	14,938	23.9
Massachusetts	Dec. 31, 1882	47,155	23.8
Michigan	Dec. 31, 1876	45,172	25.7
New Jersey	June 30, 1883	24,430	21.5
Rhode Island	Dec. 31, 1881	6,761	24.4
Vermont	Dec. 31, 1876	7,212	21.8

The average for these States is 23.5 births annually for each 1,000 inhabitants.

UNITED STATES, IN DIFFERENT CITIES.

For 1878.	Total number of births.	Ratio to 1,000 of population.	For 1883.	Total number of births.	Ratio to 1,000 of population.
Philadelphia, Pa.	18,346	20.9	New York, N. Y.	28,972	21.9
Washington, D. C.	3,791	23.6	Brooklyn, N. Y.	11,250	18.0
Milwaukee, Wis.	3,004	24.3	Baltimore, Md.	7,904	16.8
New Haven, Ct.	1,905	31.7	Boston, Mass.	11,302	28.2
Mobile, Ala.	608	15.2	Cincinnati, O.	7,956	28.4
Concord, N. H.	236	17.3	Richmond, Va.	1,939	27.8
			St. Louis, Mo.	8,835	22.0

The average for these cities is 20.4 births annually for each 1,000 inhabitants. The largest ratio occurred in New Haven, Ct., where it was 31.7 to each 1,000 inhabitants, and the smallest in Mobile, Ala., where it was only 15.2 to each 1,000; but in the latter city the returns probably fall much below the actual number.

FOREIGN COUNTRIES, FOR 1882.

	Total number of births.	Ratio to 1,000 of population.		Total number of births.	Ratio to 1,000 of population.
England & Wales	889,014	33.7	Switzerland	82,689	28.8
Scotland	126,182	33.3	German Empire	1,702,248	37.2
Ireland	122,648	24.1	Prussia	1,035,557	37.3
Denmark	65,070	32.4	The Netherlands	146,454	35.3
Norway	59,388	30.9	Belgium	176,345	31.2
Sweden	134,300	29.4	France	935,566	24.8
Austria	867,241	38.9	Italy	1,061,094	37.1
Hungary	622,226	44.6	Spain (1870)	599,786	35.4

The general average in the continental countries is 34.1 births annually to every 1,000 of population. The smallest ratio is in France (24.8), while the largest is in Hungary (44.6).

In England the birth-rate was somewhat higher in 1877 than in later years, it then reaching 36.2 to every 1,000 of population.

FOREIGN CITIES, FOR 1878.

	Total number of births.	Ratio to 1,000 of population.		Total number of births.	Ratio to 1,000 of population.
London	129,184	33.3	Heidelberg	908	38.6
Manchester	13,710	38.0	Vienna	27,670	38.0
Edinburgh	7,341	34.0	Copenhagen	8,188	36.8
Dublin	9,513	30.2	Amsterdam	10,958	36.0
Brussels	5,740	32.0	Geneva	1,798	26.1
Paris	55,324	27.3	Alexandria (Egypt)	8,764	41.3
Marseilles	9,490	29.7	Montreal (Canada)	6,402	47.6
Rome	7,669	27.1	Havana (Cuba)	4,975	19.9
Naples	15,313	31.2	Melbourne (Aus.)	8,678	33.6
Berlin	44,073	42.6	Moscow	25,026	41.5
Dresden	7,629	36.2			

In the above table the smallest ratio (19.9) is found in Havana, and the largest (47.6) in Montreal; the average is 36.6 births annually for every 1,000 of population.

It is stated by one writer that in European cities of 200,000 inhabitants the annual birth-rate is about 7,000, or 28.5 births to each 1,000 of population.

The Ratio of Males to Females in the Annual Birth-rate.

UNITED STATES.

	For the year ending	Number of males to 100 females.		For the year ending	Number of males to 100 females.
Connecticut	Nov. 30, 1883	105.7	Rhode Island	Dec. 31, 1881	107.2
Massachusetts	Dec. 31, 1882	105.9	Vermont	Dec. 31, 1876	108.8
Michigan	Dec. 31, 1876	108.0			

The average in these States is 107.1 male births to every 100 female births.

ENGLAND.

From 1837 to 1847, the average was 105 male births to 100 female births.

From 1868 to 1877, the average was 103.9 male births to every 100 female births.

In 1877, the ratio was 103.6 male births to 100 female births.

In 1882, the ratio was 103.8 male births to 100 female births.

In the report of 6,476 births, by Dr. Bailey, the ratio is found to be 103.1 male births to 100 female births ("Lond. Obstet. Soc. Trans.").

In another report of 2,247 births, by Dr. Cowles, the ratio is 105.3 males to 100 females ("Trans. Med. Soc. of the State of New York," 1881).

Statistics of the Annual Still-birth Rate.

UNITED STATES, IN DIFFERENT STATES.

	For the year ending	Total number of still-births.	Percentage of all births.
Connecticut	Nov. 30, 1883	386	2.5
Massachusetts	Dec. 31, 1882	1,485	3.1
Rhode Island	Dec. 31, 1881	264	3.8
Vermont	Dec. 31, 1876	188	2.6

The average for these States is 3 per cent. of all births.

UNITED STATES IN DIFFERENT CITIES.

For 1878.	Total number of still-births.	Percentage of all births.	For 1883.	Total number of still-births.	Percentage of all births.
Philadelphia, Pa.	908	4.8	New York, N. Y.	2,697	8.9
Washington, D. C.	407	10.7	Brooklyn, N. Y.	1,082	9.6
Milwaukee, Wis.	171	5.6	Baltimore, Md.	701	8.8
New Haven, Ct.	64	3.3	Boston, Mass	509	4.5
Mobile, Ala.	108	17.7	Cincinnati, O.	410	5.1
Concord, N. H.	8	3.3	Richmond, Va.	164	8.4
			St. Louis, Mo.	709	8.0

The average number of still-births for these cities is 7.6 per cent. of all the births reported. The largest proportion occurred in Brooklyn, where it reached 9.6 per cent. The smallest occurred in Boston, where it was 4.5 per cent.

FOREIGN COUNTRIES.

In the "Transactions of the London Obstetrical Society," vol. xiv., there is found the following table of the still-birth rate in 1869:

	Percentage of all births.		Percentage of all births.
Netherlands	5.64	Prussia	4.33
Belgium	4.72	Hanover	4.00
France	4.63	Bavaria	3.74
Saxony	4.49	Austria	1.64
Norway	4.46	Italy	1.94

The average number of still-births in these countries is 3.95 per cent. of all births.

In the same journal is found the following table for the year 1871:

	Percentage of all births.		Percentage of all births.
Prussia	2.29	Hanover	4.22
Sweden	2.64	Mecklenburg-Schwerin	3.70
Saxony	4.43	Schleswig and Holstein	4.60

The average number of still-births, according to this table, is 3.64 per cent. of all births.

FOREIGN CITIES, FOR 1878.

	Total number of still-births.	Percentage of all births.		Total number of still-births.	Percentage of all births.
Brussels	363	6.3	Geneva	88	4.8
Marseilles	723	7.6	Alexandria (Egypt)	388	4.6
Naples	905	5.9	Moscow	988	2.7
Berlin	1,761	3.9	Havana (Cuba)	206	4.2
Dresden	364	4.7	Montreal	196	3.0
Vienna	1,552	4.9			

In the foregoing table the smallest ratio (3.0) occurred in Montreal, and the highest (7.6) in Marseilles. The average ratio for these cities is 4.8 per cent. of all births.

In St. Petersburg, in 1807, the number of still-births reported was equal to 0.7 per cent. of all births; in Russia generally it was equal to 0.8 per cent.

In 1822 the general average of several continental districts was 1 still-birth to 20 living-births.

The reports of the Dublin Lying-in Asylum show that 6.3 per cent. of the births in that institution were still-births.

Dr. West (*Lancet*, 1859) says that in England 4 per cent. is the ratio of still-births in country practice; Dr. Anderson Smith says it is 4.9 per cent.

Statistics of Sex in Still-births.

In Italy, in 1869, the total number of still-births reported was 14,209; of these 8,269 were males and 5,940 females; the greater size of the male children probably explains the disproportion.

In the State of Connecticut, out of 386 still-births, 201 were males and 121 were females; the sex of 64 was not reported.

Of 1,485 still-births in Massachusetts, 807 were males and 602 females; in 76 the sex was not reported.

Of 646 still-births in Michigan, 356 were males and 258 females; in 32 the sex was not reported.

(For statistics of multiple births, see article on Superfœtation.) *William H. Murray.*

BISMUTH. 1. GENERAL MEDICINAL PROPERTIES OF COMPOUNDS OF BISMUTH.—Experiments upon animals have shown that impregnation of the blood with bismuth produces poisonous effects generally similar to those wrought by other heavy metals. So far, however, as the medicinally used compounds of bismuth are concerned, these can, if pure, be given with great freedom without constitutional disturbance—a fact commonly, and probably correctly, accounted for by the great insolubility of these compounds, by reason of which the dose fails of absorption. Poisoning, it is true, does occasionally follow a prescription of bismuth, but in such cases, when investigation has been made, the article dispensed has been pretty surely found contaminated with arsenic, a contamination dangerously common with the poorer grades of bismuth subnitrate. As regards local action, soluble bismuth compounds are mildly astringent and irritant, and insoluble preparations soothing and healing; partly, perhaps, by specific action during slow conversion to soluble forms, and partly by a mechanical sheathing of the parts while the compound is still in insoluble condition. Taken internally, bismuth compounds allay gastric pain or nausea, and tend to check diarrhœa.

2. THE MEDICINALLY USED COMPOUNDS OF BISMUTH.—The compounds of bismuth officinal in the U. S. Pharmacopœia are basic bismuth *nitrate* and *carbonate*, and a composite scale preparation containing the *citrate*.

Basic Bismuth Nitrate, $BiONO_3, H_2O$. This salt, the *magistery of bismuth* formerly so-called, or *white bismuth*, is officinal as *Bismuthi Subnitras*, Subnitrate of Bismuth. It is "a heavy, white powder, permanent in the air, odorless and almost tasteless, showing a slightly acid reaction when moistened on litmus paper, and insoluble in water or alcohol. When heated to redness, the salt gives off moisture, and afterward nitrous vapors, leaving a yellow residue which is soluble in nitric or in hydrochloric acid, and which is blackened by hydrosulphuric acid" (U. S. Ph.). This salt should not be prescribed with potassic iodide, nor with the carbonates of the alkalis. Poor quality specimens are apt to contain variable proportions of arsenic, even enough, it may be, to cause distinct poisoning in therapeutic doses. To detect this contamination, treat the specimen with sulphuric acid, evaporate to dryness, dissolve the residue in hot distilled water, and test the solution by Marsh's test for arsenic.

Subnitrate of bismuth produces the effects of the insoluble bismuth compounds already described, and is the principal medicinal preparation of the metal. The only peculiarities of its action are the production of a garlicky odor to the breath of the taker, and a blackening of the stools. The salt is given internally in doses of wide range, from 0.30 Gm., to 2.50 or even 4.00 Gm. (from five grains to a drachm), taken as a powder or suspended in mucilage. Externally it is used freely as a dusting-powder in excoriations and sores, or, suspended in water, ten per cent. admixture, in the so-called antiseptic treatment of wounds.

Basic Bismuth Carbonate, $(BiO)_2CO_3,H_2O$. This salt is officinal as *Bismuthi Subcarbonas*, Subcarbonate of Bismuth. It is "a white, or pale yellowish-white powder, permanent in the air, odorless and tasteless, and insoluble in water or alcohol. When heated to redness the salt loses moisture and carbonic acid gas, and leaves a yellow residue which is soluble in nitric or in hydrochloric acid, and which is blackened by hydrosulphuric acid" (U. S. Ph.).

Subcarbonate of bismuth is substantially a duplicate of the subnitrate in all its properties, and may be used for the same purposes and in the same manner as the latter salt.

Bismuth Citrate, $BiC_6H_5O_7$. This salt is officinal under title *Bismuthi Citras*, Citrate of Bismuth, solely for the purpose of making the next-to-be-named compound. Citrate of bismuth is made by boiling the subnitrate in a solution of citric acid. It is "a white amorphous powder, permanent in the air, odorless and tasteless, insoluble in water and alcohol, but soluble in water of ammonia" (U. S. Ph.). By dissolving this salt in water of ammonia, filtering, evaporating to a syrupy consistence, and spreading the syrupy fluid on glass plates to dry, a dry film breaking up into scales is obtained, analogous to the scale preparations of iron. These scales are officinal under the title *Bismuthi et Ammonii Citras*, Citrate of Bismuth and Ammonium. They appear as "small, shining, pearly or translucent scales, becoming opaque on exposure to air, odorless, having a slightly acidulous and metallic taste, and a neutral or faintly alkaline reaction. Very soluble in water, and but sparingly soluble in alcohol" (U. S. Ph.). The compound should be kept in small tightly-stoppered bottles, and away from the light, for, on exposure, it loses ammonia, and then fails to dissolve wholly in water. The chemical composition, as in the case of the analogous preparations of iron, is obscure; some regard the scales as containing a true double citrate of the bases, and others consider them as a mere admixture.

This preparation is unique as being a soluble compound of bismuth. It is used internally for diarrhœa, and proves astringent and mildly irritant. The dose ranges from 0.06 to 0.20 Gm. (one to three grains).

Edward Curtis.

BISMUTH, POISONING BY. The two most important compounds of bismuth are the subnitrate (basic nitrate, magistery of bismuth) and the subcarbonate. These preparations are extensively used, in doses of 0.65 to 3.9 grammes (10 to 60 grains), or more, in the treatment of diarrhœa and other forms of intestinal irritation. The subnitrate of bismuth was considered an active poison by many of the earlier writers, who state that symptoms of gastro-enteritis frequently follow its administration in doses of 1.9 to 7.7 grammes (0.5 to 2 drachms) daily. A case is recorded in which 7.7 grammes of this substance, administered to an adult, caused severe symptoms of irritant poisoning, followed by death on the ninth day. At the post-mortem examination, the tonsils, uvula, pharynx, and epiglottis were found gangrenous; the œsophagus and stomach were very red, and the whole intestinal canal was red, and here and there gangrenous, especially at the rectum (Christison).

As the subnitrate and subcarbonate of bismuth are used very freely without any bad results, it is doubtful if they can be considered irritants even in comparatively large doses. The best authorities of the present day generally agree in attributing the effects noticed by the earlier writers to impurities in the drug or to some other cause. The preparations of bismuth have frequently been found to contain arsenic in the form of arseniate of bismuth. Dr. Taylor found arsenic in three samples of subnitrate of bismuth out of five examined by him; Dr. Rogers, in eight samples out of ten. Herepath examined fourteen samples and found arsenic in all. Salisbury found arsenic in thirteen samples out of eighteen; he also examined five samples of the subcarbonate of bismuth and found arsenic in all.

There can be no doubt that the symptoms produced by subnitrate of bismuth have been sometimes due to the arsenic which it contains, as in the following cases: A physician had occasion to place himself upon a treatment of subnitrate of bismuth. After a day or two he noticed a puffiness about the eyes, and gastro-intestinal irritation. These symptoms disappeared when the use of the bismuth was discontinued, but reappeared upon the renewal of the medicine. The bismuth was found, upon analysis, to contain arsenic (Fullerton). Twenty-six grammes (400 grains) of subnitrate of bismuth was administered to a child, ten months old, over eleven consecutive days, for a moderately severe attack of inflammatory diarrhœa. After one week there was puffiness of the limbs and face; the child became severely ill, fretted, moaned, and was very restless; the diarrhœa became suddenly worse. The conjunctivæ were slightly injected, the tongue was dry, the pulse rapid, the skin hot and dry. There was no eczema. The urine was free from albumen. The symptoms disappeared when the medicine was discontinued. The bismuth was found, upon analysis, to contain 0.150 per cent. arsenic acid. Another sample was found to contain 0.240 per cent. arsenic acid (Underhill). This is the largest amount of arsenic which has been found in any of the preparations of bismuth, so far as the writer has been able to learn.

The presence of arsenic in these preparations is explained by the fact that the ores of bismuth, from which they are manufactured, contain arsenic. The processes employed for their manufacture are intended to remove all but the slightest trace of arsenic. Up to a comparatively recent date this result was frequently not attained. At the present time, however, greater care is taken in their preparation, and it is only rarely that either the subnitrate or subcarbonate of bismuth are found to contain more than the merest trace of arsenic.

It has been stated that subcarbonate and subnitrate of bismuth containing 0.129 per cent. arsenic did not produce symptoms of poisoning when administered to dogs in doses of fifteen to thirty grammes (Parral and Garnier). It is possible, therefore, that the bad effects which have been caused by these preparations are to be attributed, in some cases at least, to other causes. Idiosyncrasy has been suggested. Monneret thinks they may be due, in certain cases, to an exacerbation of the trouble for which the bismuth was administered. It has been suggested that an excess of free acid in the stomach, or acid salts, administered simultaneously with the subnitrate, may, in some cases, have converted the latter to a soluble poisonous salt of bismuth. Sobernheim explains the poisonous effects in the fatal case related by Christison, by supposing that the bitartrate of potassium, which was administered with the subnitrate of bismuth, converted the latter to an acid nitrate, which is shown by experiments on animals to be an irritant poison. Herbelin has found considerable free nitric acid in subnitrate of bismuth. The presence of this acid, or of the normal, or acid nitrate, in specimens which have been carelessly prepared, may also explain some of the symptoms which have been observed. Lead has been detected in subnitrate of bismuth (Carnot, Chapins, Linossier), but the amount was small, and it does not appear that the symptoms which have been observed in any case can be attributed to it. It is noticeable that, with improved methods of manufacture and greater care in carrying them out, cases of poisoning by these preparations have become exceedingly rare, if, indeed, they occur at all. No cases have been reported during the past few years. This fact tends to confirm the belief that the cases which have been reported were due to some of the causes which have been mentioned, rather than to any direct poisonous action of the preparations themselves.

Preparations of bismuth are frequently administered in the treatment of gastro-enteritis caused by the metallic irritants. The discovery of arsenic in the subnitrate of bismuth thus administered has been sufficient to invalidate the results of the chemical analysis in certain cases of alleged poisoning by arsenic, in which the amount of arsenic detected in the organs was small (Rogers, Reese). The attempt to account for the presence of arsenic in the

body, by suggesting that it may have come from the bismuth administered, is frequently made. It is important, therefore, whenever these preparations are given in cases of suspected poisoning, to preserve a sample for subsequent analysis if necessary.

The subcarbonate of bismuth, if pure, is undoubtedly as free from irritant properties as is the subnitrate. It is, however, more soluble than the subnitrate, and is, therefore, more liable to become converted into a soluble salt of bismuth by the acids of the gastric juice, or by acid salts if these are administered simultaneously with it. As the soluble salts of bismuth are poisonous, the subnitrate would appear to be the safer preparation when large doses are to be administered, or when the administration is to be continued for a long time.

Under the name "pearl white" the subnitrate of bismuth is used to a considerable extent as a cosmetic. The subcarbonate and oxychloride of bismuth are sometimes used for the same purpose. There is no evidence to show that they are absorbed through the skin, or that they produce, if pure, any injurious consequences, aside from stopping up the pores and thus interfering with the healthy action of the skin. Bismuth preparations containing arsenic or lead might, however, produce injurious effects when used as cosmetics.

Experiments on animals show that the soluble salts of bismuth are poisonous. The action of the following salts has been investigated: the nitrate (Orfila), the citrate of bismuth and ammonia (Stefanowitch, Lebedoff, Feder-Meyer, Mory), the acetate (Bricka), and the tartrate of bismuth and potassium (Rabuteau). The symptoms which follow the administration of these salts do not differ materially from those produced by the metallic irritants generally. The most constant post-mortem appearances are inflammation of the stomach and intestines, and a more or less extensive fatty degeneration of the liver, kidneys, and heart. Lebedoff states that the glycogen disappears from the liver after the long-continued administration of the citrate of bismuth and ammonia. The red blood-corpuscles in animals poisoned by this compound present a finely granular appearance, and masses of small free granules may be seen in the serum. These appearances point to the destruction of the blood-corpuscles (Feder-Meyer).

Absorption and Elimination.—When subnitrate of bismuth is administered, the greater part is separated with the fæces; either unchanged or in the form of sulphide. A part is absorbed. Orfila detected bismuth in the liver, spleen, and urine of dogs to which the subnitrate had been administered. Bergeret and Mayençon state that, when the subnitrate is administered, bismuth can always be detected in the urine after a few hours. They also detected it in the serous exudation of dropsy. When a few grains are given to rabbits, it can be found, in from twenty to thirty minutes, in the urine, spleen, blood, and muscles, and even eight days after the administration can be detected in all the tissues. They detected traces in the liver and kidneys of a man who had taken one gramme of the subnitrate five days before death, but failed to find it in the body of a woman who died sixty-two days after the ingestion of two grammes (quoted by H. C. Wood, Jr.).

After the administration of the soluble salts of bismuth, the metal has been detected in the urine, fæces, saliva, stomach, liver, spleen, and bones. It can be detected in the liver many months after the last administration (Bricka). It is eliminated with the urine, fæces, and, according to Dubinski, with the saliva.

William B. Hills.

BISTORT (*Bistorte*, Codex Med., the rhizome; *Polygonum Bistorta* Linn.; Order, *Polygonaceæ*). A perennial European herb with a thick tortuous rhizome, and a slender, upright, simple stem. The leaves are mostly radical and long-petioled, lanceolate, tapering above and decurrent below; two or three, which arise from the flowering stem at a distance from the ground, are short-petioled or "sessile," with sheathing petioles. The stem bears a single spike-like cluster of small rose-colored, slightly irregular flowers; the fruit is a small, three-cornered, pointed, shining achenium, with one albuminous (starchy) seed.

The rhizome is covered with rootlets, as large as the little finger, from five to fifteen centimetres long (2 to 6 inches), somewhat flattened, transversely wrinkled, variously, often excessively, once or twice doubled upon itself (Latin, *bis*, *torqueo*, *tortum*; Germ., *Schlangenwurzel*). When dry it is hard and brittle, dark brown externally, reddish-brown within, with a single circle of well-marked woody bundles; taste, astringent; odor, slight.

Chemical composition: Galli-tannic (twenty-one per cent.) and gallic acids, starch, and less important substances.

USE.—Bistort has been a well-known and considerably used astringent. The large proportion of tannic matters entitle it to rank high in this rather numerous class of medicines. Of course it is vastly exceeded in this respect by the various galls, and has no advantage over the tannic acid so easily prepared from them. It is, therefore, now but little used. It has also been employed as a source of starch.

Dose, one or two grammes (gr. xv. ad xxx.).

ALLIED PLANTS.—The genus *Polygonum* is a very large one and contains a number of familiar plants, mostly weeds. Astringency is a common quality in it. The water-pepper of Europe, *P. hydropiper* Linn., and our smartweed, *P. hydropiperoides* Michx., are acrid and irritant when fresh, like the buttercups, reddening and inflaming the skin, a property which they owe to *polyganic acid*, according to Mr. C. J. Rodemacher. "Prince's Feather," *P. orientale*, is cultivated for ornament in country gardens.

Buckwheat, *Fagopyrum esculentum* Mönch, was included in the genus by Linné. For a notice of the order see RHUBARB.

ALLIED DRUGS.—The astringents in general, tormentilla, avens (Geum), alum root (*Heuchera*), and stargrass (*Aletris*), resemble it, especially by being just about as good and just about as obsolete. Crane's bill (*Geranium*), blackberry root (*Rubus*), hardack (*Spiræa*) are indigenous plants of similar value, still in use in America. See NUTGALLS.

W. P. Bolles.

BITTERSWEET (Dulcamara, U. S. Ph., Br. Ph.; *Douce amère*, Codex Med.), *Solanum Dulcamara* Linn.; Order, *Solanaceæ*.

A familiar straggling or climbing, half woody, somewhat velvety, perennial vine, with a weak, soft stem, dull green alternate leaves, and spreading, extra-axillary cymes, of pretty star-shaped flowers. The leaves are

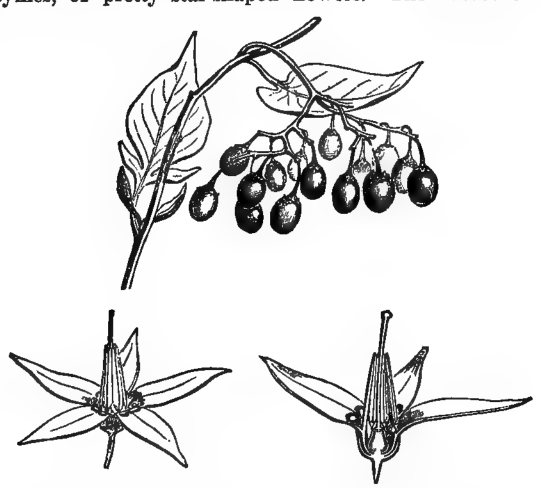


FIG. 403.—Bittersweet. Plant reduced and flower enlarged. (Baillon.)

variable, the lower heart-shaped, the middle and upper ones ovate or lanceolate, tapering above, and often irregularly and unsymmetrically cleft or lobed at the base. The flowers are perfect and regular, about one and one-

fourth centimetre (half an inch) across. The calyx is short and inconspicuous, the corolla has a very short tube, and five lanceolate pointed, lilac blue, spreading lobes. At the base of each lobe are two small greenish-yellow spots, forming all together a circle of ten at the throat of the corolla. Stamens five, with very short filaments, and large projecting bright yellow syngenesious anthers. Pistil one, style longer than the stamens, ovary two-celled, many-ovuled. Fruit an oval, shining berry, about a centimetre long, and green, light green, yellow, orange, and scarlet, according to age and ripeness. The flowers and fruit of all colors, which may be seen on the vine at the same time during the summer and fall, make it an attractive decoration for the walls and bushes over which it grows.

Dulcamara is a native of Europe and parts of Asia, but it has made itself perfectly at home in the pastures and waste places of this country. The stem is the part generally collected for medicinal use. That of the younger branches is dull green, slightly angular, and has a large pith ; that of older stems has a gray bark, and is usually hollow. The stem is always slender, even when two or three metres long, seldom exceeding one or two centimetres (two-fifths to four-fifths of an inch) in thickness. The Pharmacopœia requires the younger branches (which should be gathered in the spring or fall), and describes them as "About a fourth of an inch (six millimetres) or less, thick, cylindrical, somewhat angular, longitudinally striate, more or less warty, usually hollow in the centre, cut into short sections. The thin bark is internally pale greenish, or light greenish-brown, marked with alternate leaf-scars, and internally green ; the greenish or yellowish wood forms one or two concentric rings. Odor slight, taste bitter, afterward sweet."

The composition of Dulcamara is not very definite. Its most characteristic constituent is *dulcamarin*, discovered in 1852 by Wittstem, and at first thought to be an alkaloid, but afterward shown not to be one by Geissler. It is a yellow, amorphous powder, having the combination of tastes (bitter and afterward sweet) which has given to the plant its name. It is sparingly soluble in water, freely so in alcohol and acetic acid, but insoluble in ether and chloroform. Treated with diluted mineral acids, sugar and "*dulcamaretin*" result. *Solanine* is doubtfully present in Bittersweet in a minute quantity ; according to Schoonbroodt, it is not solanine itself, but a substance which produces it by decomposition, which really exists in the plant. It is further to be doubted whether Solanine of Bittersweet is exactly like that of the potato and other plants of the genus. *Solanine* itself is a glucoside, splitting into sugar and "*solanidine*" under the usual treatment.

This medicine has been in occasional use since the middle ages, but has no very decisive record. Its reputed efficacy in "mad dog bites," "gout," "scrofula," and "skin diseases," does not give much clue to its usefulness, if it have any. Its close relation to a number of deleterious solanine-bearing plants has made its reputation suspicious, but the records of injury, from the green plant even, are very few ; from the dried, almost none. A large quantity of a decoction made from a peck of the stems, has been taken, followed only by transient numbness, dryness of the mouth, and paralysis of the tongue ; in medicinal doses, it can scarcely be said to have any physiological action. The amount of solanine, especially in old stalks, is very small. Of the action of *dulcamarin*, the writer has no knowledge. Given in copious hot decoction, Bittersweet is probably diaphoretic and diuretic, and is still occasionally used in chronic rheumatism, as well as in psoriasis and some other chronic skin diseases. Dose—five to ten grammes (gr. lxxv. ad cl.). A fluid extract is made (*Extractum Dulcamaræ Fluidum*, U. S. Ph.), but an extemporaneous decoction is probably a better form.

ALLIED PLANTS.—*Solanum* is the type-genus of the order, and contains more than seven hundred plants, mostly inhabitants of the warmer parts of the earth. The potato and egg-plant belong to it, the tomato is scarcely removed from it. On the other hand, it contains many poisonous and disagreeable plants, like the Deadly Nightshade, *Solanum nigrum* Linn.; parts also of even its edible representatives are poisonous, like the leaves of the tomato and the stalks and sprouts of the potato.

Solanine is the characteristic alkaloid of the genus, and has been detected in most of its members where it has been sought for. It undoubtedly occurs in many others, as well as in some of the related genera. It was discovered by Desfosses in the berries of deadly nightshade in 1820, and shortly after by various observers in potato balls and sprouts, in Bittersweet, in tomato leaves, and several solanums which are common European weeds. It is usually prepared from potato sprouts, and is a white, crystalline, exceedingly insoluble substance of active poisonous properties, of a nervous-depressant character. It is hard to harmonize the different experiments made with it in detail, but it appears to produce depression of the circulation, dyspnœa, vomiting, and either cramp or debility in the extremities. The stimulation of the cardiac and respiratory functions, and the mydriasis of atropine appear to be wholly absent. Solanine is not used in medicine, but doses of two decigrammes (0.2, gr. iii.) have been taken experimentally, with the above and other unpleasant effects. For a notice of the order Solanaceæ, see BELLADONNA.

ALLIED DRUGS.—The so-called alteratives.

W. P. Bolles.

BLACKBERRY (*Rubus*, U. S. Ph.). Three species of *Rubus* are admitted into the Pharmacopœia under this title: 1. *Rubus villosus* Aiton ; Order, *Rosaceæ. Rubeæ*, the familiar High Blackberry, is a very variable plant. It has a stout, more or less prismatic stem, often five-angled and channelled, upright or oblique and arching, from one to three metres in length (three to ten feet), branching freely near the top into a one-sided head, and dying partly back, like the roses, in the winter. It is armed with prickles to the top ; those of the trunk and larger branches are recurved, and very stout and sharp. The leaves are quinate, pubescent ; leaflets ovate, pointed, sharply serrate ; petioles and midribs prickly beneath. Flowers in axillary, many-flowered, pyramidal racemes. Fruit large, from one and a fourth to two and a half centimetres long (one-half to one inch), oblong or cylindrical, consisting of numerous small, black, shining drupes, crowded on a long, soft receptacle. The taste of the fruit, when fully ripe, is sweet, with a slightly mawkish, mulberry-like flavor. The Lawton Blackberry is a cultivated variety, with very large, juicy, and agreeable fruits. 2. The low, or creeping Blackberry, Dewberry, *Rubus canadensis* Linn., has a round, slender, prostrate and rooting, sparingly branching stem, with fewer and weaker prickles, and ternate leaves. The racemes are fewer flowered, and the flowers larger than the preceding. The fruit is shorter, as broad as long, and consists of fewer, larger, and very sweet and juicy drupes. 3. *Rubus trivialis* Michx, is a southern species, with procumbent stem, evergreen leaves, and almost solitary flowers. All the above are natives of the United States; their use as a medicine is also confined to this country. The berries of the first two are common dessert fruits, and are also manufactured into jams, syrups, and even wines, which have a popular reputation for being astringent ; the leaves are astringent, but not much used.

"Blackberry root" consists of the bark of the root of either of these species (that of *Rubus villosus* is what the writer has oftenest seen). It is in tough, flexible bands, reddish brown or ash-colored externally, pale brown on the inner side ; the smaller roots are often entire, but as the wood is inert, samples consisting of the bark alone should be preferred. The taste is strongly astringent, slightly bitter ; odor, none.

Constituents : Some form of tannic acid, and a very little bitter principle.

USES.—Blackberry root is a pleasant and efficient astringent ; its tonic properties are usually mentioned, but must be very slight. It is applicable to the same conditions as the allied Rosaceæ referred to below, and has about the same value. Nearly every country has its list

of indigenous astringents, whose use seldom extends beyond its borders, not because they are not good, but because they are all of about equal value. In the aggregate they are much more often given than pure tannic or gallic acids, but whether with good reason or not, it is difficult to say. Blackberry is not best given in substance, as the dose involves a good deal of woody tissue, but for computation the dose of it may be assumed as from two to four grammes (gr. xxx. ad ʒ i.). The fluid extract (*Extractum Rubi Fluidum*, U. S. Ph.) represents it entirely, strength $\frac{1}{1}$; from this, a syrup (*Syrupus Rubi*, U. S. Ph., not *Rubi Idæi*), strength $\frac{1}{8}$, is made, which is pleasant, and may be taken when the large amount of syrup is not an objection.

Allied Plants.—*Rubus* is a large genus, comprising more than a hundred species, inhabiting mostly the temperate and tropical zones of the northern hemisphere. They include numerous kinds of "blackberries," in which the receptacle (core) falls away with the fruit, and also the raspberries (see Rubus Idæus), thimbleberries, etc., in which the drupes separate in a mass from the receptacle, as little hollow cups or domes. *Rubus Odoratus* Linn., of the Western States, with large handsome pink flowers, is occasionally cultivated for ornament. Astringent leaves and roots, and acidulous, sweet fruits, are common characteristics of the genus. The Spiræas, strawberries, potentillas, etc., are neighboring genera, generally with astringent qualities. For a note of the entire order, see Roses.

Allied Drugs.—See Nutgalls. *W. P. Bolles.*

BLACK DEATH, a great pestilence of the fourteenth century, which devastated Asia, Europe, and Africa. The principal symptoms were the outbreak of inflammatory boils and buboes, and the formation of black spots upon the skin (petechiæ); hence the disease was called, in the north of Europe, the Black Death; but in Italy, from the very great fatality, la Mortaglia Grande, or the Great Mortality. The black death was modified oriental plague.

The best clinical history of the disease is that of Guy of Chauliac, who saw the black death at Avignon, in 1348, and again in 1360. The attack varied in different cases, but usually it set in with fever and a hæmorrhage, most commonly from the nose, but frequently from the lungs or stomach. This loss of blood was in many cases of such severity as to carry the patient off in two or three days. After the hæmorrhage had ceased the characteristic boils and buboes appeared, attacking the lymphatic glands of the groin and axilla, as well as the skin of the surface generally. It was soon noticed that the disease was highly contagious, and that the virus was present in the evacuations of the sick.

In the East, the symptoms differed somewhat, and inflammation of the lungs was said to have complicated the disease.

Boccaccio has left us a graphic account of the "great mortality" as it appeared in Florence. The disease "in the spring of the foregoing year (1347), began to show itself in a sad and wonderful manner; and different from what it had been in the East, where bleeding from the nose is the fatal prognostic; here there appeared certain tumors in the groin, some as big as a small apple, others as an egg; and afterward purple spots in most parts of the body; in some cases large and but few in number, in others less and more numerous, both sorts the usual messengers of death." Almost all attacked died within the first three days, for the most part entirely without fever.

In Germany, the hæmorrhages were absent, the whole course of the disease being milder, though the chronicles of Strasburg state that in the year 1349, 16,000 died in that city.

The disease in England resembled that described as occurring in Avignon. There were hæmorrhages followed by the outbreak of boils and buboes. It was some time after the outbreak of the plague in England, that it was discovered that incision of the buboes permitted the outflow of pus, and favored recovery.

The black death first appeared in Dorsetshire, then attacked Devon and Somerset, and rapidly proceeded to Gloucester, Oxford, and London. The mortality was very great. Contemporary writers report that but one in ten of the inhabitants escaped.

The crews of ships carried the disease to Norway and Sweden, where it raged with still greater severity than in Southern Europe. Finally, two years after its first appearance in Europe, it found its way to Russia.

The Causes of the Black Death.—Various causes have been assigned to the many plagues and pestilences of the middle ages. In the light of our present experience it may confidently be stated that malhygiene was the one and only cause. The fourteenth was probably the dirtiest century in the history of Europe, and, as a consequence, in it occurred the greatest loss of life.

Among the causes mentioned by historians were atmospheric disturbances, which were said to have occurred in the few years preceding the actual outbreak of the plague. There was a great drought in China in 1333, followed by extensive floods. Hecker believed that China was the birthplace of the black death. There were also records of mighty earthquakes in 1336. On January 25, 1348, Greece, Italy, and neighboring countries were much shaken. From China the black death passed through Central Asia, along the north shore of the Caspian Sea, thence north of the Black Sea to Constantinople, which was then, as it is now, the distributing point of infection for all Europe.

Mortality.—Allowance being made for exaggeration, the records show a very great loss of life during the years of prevalence of the pestilence. It was reported to Pope Clement at Avignon, that throughout the East, probably with the exception of China, 23,840,000 people had fallen victims (Barnes). Hecker collected the following figures from some of the more credible contemporary histories: There died in Florence of the black plague, 60,000; in Venice, 100,000; in Marseilles, in one month, 16,000; in Paris, 50,000; in St. Denis, 14,000; in Avignon, 60,000; in Strasburg, 16,000; in London, 100,000; in Norwich, 51,100.

The measures adopted for the suppression of the disease were in keeping with the intelligence of the period. The Paris Faculty gave it as their opinion that the plague was the result of poisonous emanations from the waters and that prevention might be accomplished by burning large quantities of vinewood, green laurel, or any other green wood, with the addition of wormwood or chamomile.

The separation of the sick from the healthy seems to have been practised only among the wealthier classes.

R. L. MacDonnell.

BLADDER OF THE MALE. Anatomy.—The Urinary Bladder (vesica urinaria) is a membrano-muscular sac which serves as a reservoir for the urine that escapes constantly from the kidneys. It is oval in shape, and lies immediately behind the symphysis pubis, with its long diameter horizontal when the body is erect. Its posterior wall is in relation with the rectum in man, and with the uterus and upper portion of the vagina in woman. The antero-posterior diameter is consequently shorter in woman, but the lateral portions of the organ are so much more distensible than in man that the female bladder has nearly the capacity of the male.

The bladder is usually described as having an apex, a body, a fundus or base, and a neck.

The *apex*, which, when the organ is empty, reaches barely to the top of the symphysis pubis, is carried upward and forward as the urine collects, until, in an overdistended bladder, it may rise high into the abdominal cavity, in which case it usually inclines to the right side. It is attached to the umbilicus by a fibro-muscular cord, the remains of the urachus (ligamentum vesico-umbilicale medium). The *body* of the bladder rests in front upon the posterior surface of the pubes, and upon the internal obturator muscles. When distended, it rises against the anterior abdominal wall. Its sides are connected with the umbilicus by the fibrous cords which are the obliter-

ated portions of the hypogastric arteries (ligamenta vesico-umbilicalia lateralia, chordæ umbilicales).

The peritoneum clothes all of that portion of the bladder wall posterior to the insertion of the urachus, and reaches down upon the sides as far as the obliterated hypogastric arteries. Posteriorly it is reflected on to the rectum from a line just above the entrance of the ureters. All of the bladder wall below and in front of these points is devoid of serous covering. The *fundus* (base or floor) of the bladder is directed downward and backward. It rests in the male upon the rectum, and has attached to it on either side a seminal vesicle and vas deferens. These, commencing on the sides and running forward toward the prostate, form, with the recto-vesical fold of the peritoneum, a triangular space. Within this triangle, which is easily reached by the finger in the rectum, the bladder is covered neither by peritoneum nor by other important structure. (In rare cases the peritoneum may, when the bladder is empty, reach down to or even partly over the prostate.) When the bladder is distended, the recto-vesical fold of peritoneum is lifted up, and this triangular space is, by so much, increased in extent.

The so-called *neck* of the bladder has no real anatomical existence, *i.e.*, the bladder does not become funnel-shaped

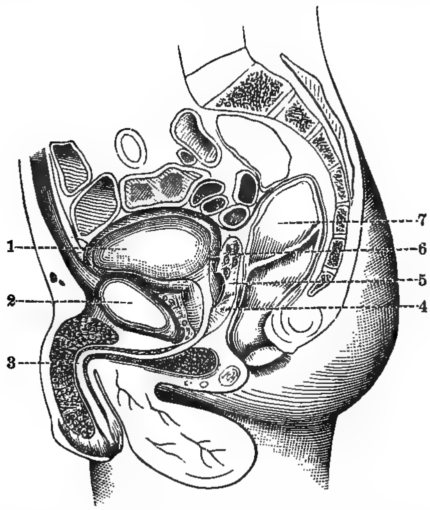


FIG. 404.—(After Braune.) 1, Cavity of the bladder (the dotted line also marks the fold of peritoneum in front of the bladder); 2, pubic bone; 3, urethra; 4, prostate gland; 5, ejaculatory duct; 6, seminal vesicles; 7, rectum.

or narrow as it approaches the urethral opening. If the expression "neck of the bladder" is to be preserved, the prostatic urethra should properly bear this name.

The bladder is held in place by numerous ligaments. Of these the obliterated urachus (ligamentum vesico-umbilicale medium) and hypogastric arteries (ligamenta vesico-umbilicalia lateralia) have been already described. Besides these, there are the pubo-prostatic ligaments (ligamenta pubo-prostatica, media et lateralia), which extend backward from the pubes to the prostate and contiguous portion of the bladder, and a rather loose fascia between the rectum and the bladder, which serves to steady the latter when full, and is known as the fascia recto-vesicalis. There are besides five false ligaments, two posterior, two lateral, and one superior. These are merely folds of the peritoneum where it is reflected from the bladder to the rectum, the sides of the pelvis, and the umbilicus.

Upon section, the bladder is seen to be lined with a soft, pink mucous membrane, which, when the viscus is empty, is thrown into irregular folds. The interlacing bundles of muscular fibres cause also little prominent lines to stand out. This prominence of the muscular fibres is best seen in a bladder which has become hypertrophied in consequence of some obstruction to the easy passage of the urine. At the part of the bladder most dependent in the upright position is the orifice of the urethra, around which the mucous membrane is thrown into little longitudinal folds. This internal meatus of the urethra is not at the bottom of a funnel-shaped depression, but when the bladder is full, opens flush upon the evenly rounded wall. The orifices of the ureters lie in the fundus of the bladder, about one and a fourth inch apart, and the same distance behind the urethral opening. The ureters take a slanting course in their passage through the bladder wall, and run for about half an inch between the muscular and mucous coats, thus forming a sort of valvular arrangement which serves to prevent the regurgitation of urine through them. This triangular portion of the bladder wall lying between these three openings is known as the trigone (trigonum Lieutaudii). The mucous membrane covering this portion is more intimately adherent to the underlying tissues than that lining the rest of the organ, and consequently remains smooth when the bladder is contracted. The trigone on the inside of the bladder overlies very closely the triangle already mentioned as formed, on the outside, by the vesiculæ seminales and the recto-vesical fold of peritoneum. From the middle of the line joining the orifices of the ureters a slight elevation extends forward toward, and sometimes into, the orifice of the urethra. This, known as the *uvula vesicæ*, is caused by a thickening of the submucous tissues. It is generally indistinct, but sometimes well developed.

The wall of the bladder contains four layers. The serous or peritoneal coat covers the posterior surface and top of the bladder, from the entrance-points of the ureters to the attachment of the urachus, and is reflected from it upon the parts about. Next beneath the serous comes the muscular coat made up of unstriped muscular fibres, which may be described in three layers—an external layer of longitudinal fibres, a layer of circular, and a deep layer of longitudinal fibres. The outer longitudinal fibres, which are known as the *detrusor urinæ* muscle, take their origin in front from the pubes (musculi pubovesicales), and from the prostate; behind they arise from the prostate in the male, from the vagina in the female. Starting from these fixed points, the fibres spread out over the anterior and posterior surfaces of the bladder, and interlace over its summit and sides. A few fibres are continued up along the urachus. The middle circular layer is thin, and over the upper part of the bladder the fibres interlace in a rather irregular manner; they become more circular in the lower part of the organ, and at the junction of the bladder and prostate they form a firm encircling band which runs over insensibly into, and cannot be really separated from, the circular fibres of the prostate.

Though bearing the name of *sphincter vesicæ*, this band, according to Henle, does not play the part of a sphincter, but this function is performed by the prostate. The third or deep longitudinal layer is thin and irregular in arrangement, and lies just below the mucous membrane. Between the muscular coat and the mucous membrane is interposed a layer of areolar tissue, containing many elastic fibres and blood-vessels.

The mucous membrane is soft and smooth. It is covered with several layers of flat and round epithelial cells, and contains numerous mucous glands, especially in the part adjacent to the urethral opening. The glands are provided with cylindrical epithelium.

The bladder derives its blood-supply mainly from branches of the internal iliac arteries. The superior vesical arteries, which are the remaining pervious portions of the hypogastric arteries, are direct branches of the internal iliacs. The inferior vesical arteries are given off from the anterior division of the internal iliac. In the female the uterine arteries also send branches to the bladder.

The veins, which form complicated plexuses about the neck, sides, and base of the bladder, empty into the internal iliac veins.

The lymphatics follow the course of the arteries and veins. The nerves are derived from the hypogastric plexus of the sympathetic, and from the sacral plexus of

the cerebro-spinal system. The filaments derived from the former source are distributed to the body, those from the latter source to the base and neck of the organ.

Physiology.—The bladder serves simply as a reservoir for the urine which is brought to it through the ureters from the kidneys. As it becomes distended, the internal sphincter relaxes, or, according to some authorities, is pulled apart by the fibres of the detrusor urinæ muscle which are inserted into it. When it opens, the urine enters the pars prostatica urethræ, and is then only held back by the cut-off muscle of the urethra (musculus compressorius urethræ, known also as the external sphincter). The pressure of the urine in this deep portion of the urethra induces an almost irresistible desire to micturate. When the will finally allows the compressor muscle of the urethra to relax, the passage for the urine is open, and the contraction of the bladder wall, especially of the detrusor urinæ muscle, empties the organ. The act of micturition is also helped by the pressure of the abdominal muscles.

Embryology.—The urinary bladder is formed from the portion of the allantois that is shut within the body by the closure of the umbilicus, and it consequently remains connected with the navel by the upper, obliterated portion of the allantois (urachus). When the umbilicus closes, the bladder and rectum form together one cloaca, and are gradually separated by a partition wall that grows down between them, and ultimately forms the perineum.

Malformations.—The development of the bladder may be arrested at various stages in its progress. Occasionally the septum which divides the rectum from the bladder is wholly or partially wanting, so that they freely communicate with each other, or, in extreme cases, form together a large pouch (cloaca) into which the intestine and ureters open. This condition of things may be associated with imperforate anus. Entire absence of the bladder has been reported, in which case the ureters opened directly into the urethra.

The most common fault of development, however, is the absence of the anterior vesical wall. This deformity, known as *exstrophy of the bladder*, is far more common in males than in females. It consists in a failure of union of the two halves of the body along the abdominal surface. The anterior wall of the bladder, and the abdominal wall over it, are wanting, and the pubic bones are generally separated by a considerable interval. The posterior vesical wall is consequently exposed to the air, and is pressed forward by the intestines behind it, thus forming a prominent tumor which may reach the size of the palm of the hand. This bulging bladder wall, owing to the constant irritation to which it is subjected, is much reddened and inflamed, and is usually covered with stringy alkaline mucus. In the lower part of this protruding mass may be seen the openings of the ureters, which are revealed by the constant little jets of urine escaping from them. They are sometimes much dilated. The rudimentary penis, which is always in a condition of complete epispadias, usually exists merely as a slight prominence, but may be of considerable size. It sometimes even retains a considerable power of erection, a point to be considered in the fitting of an apparatus. In connection with exstrophy are associated not infrequently herniæ of one or both sides.

If the fault of development be not so extensive as in complete exstrophy, the abdominal walls may unite entirely up to the umbilicus, which fails to close and leaves a fistulous communication with the bladder through the still patent urachus. An even lesser degree of the same deformity is represented by a prolongation of the bladder up into the lower portion of the urachus. Sometimes the canal may be shut off from the bladder and form a cyst, or a series of cysts.

The suffering in a case of complete exstrophy is usually very great.

Plastic operations are sometimes successful in covering in the greater part of the bladder wall, leaving a fistulous opening, usually of considerable size, from which the urine constantly escapes, and over which a urinal must be worn. Of the plastic operations, the one devised by Professor Bigelow is the best. It consists in the dissection of the mucous membrane from the exposed bladder wall, and the implantation of a flap from the neighborhood over the denuded surface. The raw surfaces adhere and obliterate the bladder, leaving only a small opening opposite the ureters. Sonnenburg advises, in children, the simple removal of the bladder mucous membrane down to the ureters, leaving the surface to granulate and heal over.

As a urinal is always a necessity in any event, it is generally advisable to fit one over the exstrophied bladder at the outset, without subjecting the patient to the discomforts and dangers of an operation. The rubber urinals manufactured for these cases are unsatisfactory, as they press upon and irritate the mucous membrane. The best form is a silver or German silver shield, which arches over and protects the bladder, with a dependent portion into which the urine runs, and which communicates by a tube with a rubber bottle strapped against the leg. In order to get a well-fitting apparatus, it is a good plan to have first made a flexible metallic ring, large enough to encircle the bladder. This is then bent and adapted to the inequalities of the surface, and, finally, the edge of the shield is fitted and soldered to it. The whole is held in place by a belt and perineal band.

Besides these malformations due to defective development, there are sacculated bladders in which, occasionally, the sacculi may even exceed the bladder in size. They are formed by herniæ of the mucous coat through the interstices of the muscular fibres, and may be recognized by the absence of a muscular coat over them. The bladder may also be divided into chambers, by partitions springing out from the walls.

Hernia of the Bladder.—This displacement may be congenital or acquired. Like other herniæ, it is sometimes brought about by violence or over-exertion. It may appear at any of the orifices in the lower abdomen through which other herniæ occur. The most common forms are inguinal in men, and vaginal or femoral in women. The hernial sac usually contains also portions of intestine and omentum, but may be occupied by a part of the bladder alone. The portion of the bladder in the sac is usually not covered by peritoneum, although exceptionally it may be. The presence of the bladder in a hernial sac is sometimes brought about by its adhesion to the intestine or omentum, which then drags it down with it. M. Berger observed a case of inguinal hernia in which a portion of the bladder wall was drawn into the sac by adherent omentum. The bladder was opened by mistake, but was closed again by sutures, and the vesical wound fastened close to the inguinal opening. Some days later a fistula formed, which discharged urine intermittently, and closed spontaneously at the end of two months.

Inflammation may occur secondarily in a cystocele, it being the result of stagnation and consequent fermentation of urine.

The diagnosis is to be made by the aid of the catheter, the tumor being emptied when the urine is drawn from the bladder. Pressure on the tumor, too, hastens the flow of the urine.

The treatment consists in returning the hernia if possible. If this cannot be done the sac should be supported by a suspensory bandage, and the escape of the urine should be aided by pressure during micturition.

Wounds of the Bladder.—The protected situation of the bladder renders it little liable to injury. In fracture of the pelvis, a sharp point or fragment of bone may penetrate its wall, or it may be injured by gunshot wounds, or by puncture with a sharp instrument. The treatment of this class of cases will be considered more at length under "Rupture of the Bladder." The bladder may also be wounded by the unskilful use of instruments in lithotrity, or may be incised by accident during ovariotomy, hysterectomy, or other abdominal operation. In this latter case, if at once carefully stitched up, the wound usually heals without serious trouble. The operation of lithotomy, or the removal of a tumor from the vesical wall, naturally leaves a wound of the bladder, which is to be treated by free drainage and careful antiseptic irrigation.

Rupture of the Bladder.—Ruptures of the bladder are either idiopathic or traumatic. According to their location, they may be also classed as intraperitoneal and extraperitoneal. Among the extraperitoneal are to be reckoned the partial and the subperitoneal.

Idiopathic ruptures usually occur in bladders altered by disease. A long-continued obstruction to the passage of the urine, as from a stricture or enlarged prostate, favors the formation of little herniæ of the mucous membrane through the meshes of the muscular tunic, and an over-violent strain during some exertion, or in the effort to empty the bladder, may rupture one of these little thin diverticula. The vesical wall is also sometimes weakened by ulceration, simple or malignant, and is thus rendered especially liable to give way. During labor, the distended bladder may be ruptured by compression between the abdominal wall and some part of the child or instrument used in the birth. The rent in this case may be either into the vagina or peritoneal cavity.

Rupture of the healthy bladder is rarely produced, except by external violence in the form of a blow or crush. Probably it is sometimes also brought about by great muscular exertion when the bladder is distended, even though it be healthy. In traumatic ruptures, the bladder is almost always full at the time of the traumatism.

Great violence to the hypogastrium is capable of producing a tear in the anterior wall of an empty bladder. This accident is to be explained as follows: The force applied to the hypogastrium carries the upper portion of the bladder, which is attached to the abdominal wall by the peritoneum and urachus, violently backward. The lower part of the bladder is held by the prostate, which is fixed by the pelvic fascia, and consequently a rent occurs in the anterior vesical wall just above the prostate. This is often accompanied by a considerable stripping up of the peritoneum. Intraperitoneal rupture uncomplicated can only occur when the bladder is full.

Symptoms.—When a rupture occurs a feeling of giving way or of a tear is often experienced. If the bladder has been painfully stretched by long retention, the first feeling may be of relief. Soon, however, pain follows, and is referred to the whole abdomen or to the pelvic region. This is followed in the majority of cases by shock and inability to walk. There may be desire, but want of ability, to micturate. Catheterism is usually easy, but obtains only a little bloody urine; not infrequently, on pushing the catheter further " second escape of fluid is obtained.

Many of these symptoms may, however, be wanting. The pain is sometimes not very great; micturition may be possible, though even then usually difficult. The catheter may draw clear urine.

The *treatment* of rupture of the bladder has probably, until very recently, been too conservative in character. Rivington and Reginald Harrison both favor a perineal incision as soon as the diagnosis is made. If by exploration with the finger the rent is found to be extraperitoneal, a drainage-tube of good size should be introduced through the perineal wound. For an extraperitoneal rent, Rivington advises further suprapubic incision to prevent urinary infiltration. Rivington's advice, in case of an intraperitoneal rent, is that the abdomen be immediately opened and cleansed, the rent being left to heal by itself, or sewed up according as future experience shall dictate. Harrison does not advise the performance of laparotomy unless there is evidence of considerable hæmorrhage, or unless there is difficulty in providing satisfactory drainage. The favorable results obtained by suture of clean-cut wounds of the bladder would certainly encourage the hope of success from sewing up rents after paring away ragged edges.

Tumors of the Bladder.—Tumors of the bladder may be classified as follows, in the order of their frequency:

Papilloma, carcinoma (carcinoma papillosum, epithelioma), myoma, fibroma, sarcoma.

Papillary tumors form, according to Professor Guyon, nine-sixteenths, according to Sir Henry Thompson, six-tenths, of all the new growths of the bladder. They are made up of very vascular branching papillæ, clothed with irregularly cylindrical epithelium. They are either pedunculated or sessile, and upon their character in this respect depends the difficulty of their removal. Their favorite seat is in the neighborhood of the trigonum, and they may attain the size of a pigeon's egg, or even larger.

They give rise to intermittent hæmaturia, which may finally become quite constant and severe. Occasionally, by their pressure, they cause obstruction to micturition or to the entrance of urine through the ureters. Finally, cystitis is usually associated with them. The hæmaturia may, however, exist for a number of years before other symptoms appear. Although benignant in their character, they finally cause death by the changes that they bring in their train. That they may take on a carcinomatous character seems also borne out by facts.

Treatment should consist in a radical removal, if possible. Thompson favors opening the bladder by the median perineal incision into the membranous urethra, with subsequent dilatation of the prostatic portion. Guyon, on the other hand, prefers the suprapubic operation. He holds that by this incision less important structures are injured, and a better opportunity is offered for thorough investigation of the bladder and careful removal of the new growth. If this operation is selected it should be performed in the manner described by Petersen (see Lithotomy). The tumor itself may be twisted off with forceps if it be pedunculated, or scraped away with a sharp spoon if sessile.

Primary carcinoma of the bladder occurs either in the form of papillary cancer, in which an indurated cancerous base is covered by papillæ resembling those of the simple papilloma, or as an epitheliomatous ulcer with hard indurated base and edges. Scirrhus is rarely met with, as is also an encephaloid form of disease.

The symptoms resemble those of papilloma, but are sooner or later associated with severe lancinating pains in the bladder and its neighborhood. The cancerous cachexia is often very marked.

The treatment is palliative. An incision in the perineum gives the opportunity to confirm the diagnosis, and often to remove considerable portions of the growth with great relief of pain. This incision, too, by affording adequate drainage, saves the patient from the pain of micturition, which is often very severe when fragments of the growth are passing. The subsequent history, if the immediate effects of the operation are recovered from, is of the slow generalization of the cancer with symptoms varied according to the organs implicated, the liver being almost invariably the seat of secondary deposits.

The *myomata* and *fibromata* can hardly be considered separately, as they usually occur in a mixed form, myofibroma or fibro-myoma containing both fibrous and muscular elements. They are very rare. Gussenbauer and Volkmann have both met with and removed tumors of this character. Gussenbauer's patient recovered, while Volkmann's died. Tumors of this class may give rise to symptoms of obstruction, but do not, as a rule, cause hæmaturia or cystitis.

Primary sarcoma is extremely rare. The author has seen tumors of the prostate and bladder secondary to a round-celled sarcoma of the testis.

Besides the regular tumors mentioned above *cysts* may rarely occur. They are sometimes congenital and contain hair, bones, etc.

Neuroses of the Bladder.—*Spasm* of the bladder when not due to inflammation, is probably in the great majority of cases dependent upon an increased sensibility of the prostatic urethra (neuralgia of the neck of the bladder), causing by reflex action an excessive contraction of the detrusor urinæ muscle. (See Diseases of the Prostate.)

Paralysis of the bladder is usually consequent upon some disease or injury of the nervous system. The lesion may exist in peripheral nerve-trunks, or may be located either in the reflex or in the motor centre (spinal cord or brain). Very rarely it occurs functionally, as a result of reflex irritation.

The loss of power may be total or partial. When the

paralysis is complete, which occurs usually in connection with paraplegia, the sphincters, both voluntary and involuntary, are also paralyzed, and after the accumulation of the urine produces a tension in the bladder great enough to overcome the resistance in the urethra, a leaking of the overflow commences. As sensation is lost in these cases the distention of the bladder and escape of the urine is often not perceived by the patient.

If the paralysis comes on slowly, as it may do in cases of spinal sclerosis and in Pott's disease, it first makes itself known by the diminution in the force of the stream, and the increase in the time occupied in urination. When the paralysis is extreme the pressure of the abdominal muscles furnishes almost the only driving power, and the stream dribbles perpendicularly from the meatus.

As the act of urination becomes more and more incomplete the amount of residual urine slowly increases, until finally the bladder becomes distended and the overflow begins to escape, either intermittently or constantly. In either case a partial power of urination may be preserved.

When the distention becomes extreme, the pressure is transmitted back to the kidneys, and may be so great as to cause suppression of urine and uræmia.

Besides this true paralysis, dependent on nervous lesions, there is also occasionally a partial or temporary loss of power, dependent upon general disturbances of the nervous system, such as hysteria, nervous prostration, and the debility following sexual excesses.

Atony of the bladder, by which is understood a weakness or loss of contractile power of the muscular coat, is not infrequently seen as a result of over-stretching, which may be brought about by excessive voluntary retention, or may be the result of obstruction in the prostate or urethra. This loss of power is not dependent upon any interference with the nervous supply to the bladder, but is analogous to the enfeebled condition induced in any voluntary muscle which is persistently kept upon the stretch.

The diagnosis of paralysis or of atony of the bladder, when existing in any marked degree, is usually not difficult, although sometimes the constant escape of urine from an over-filled bladder leads to the erroneous idea that true incontinence exists. This mistake will be avoided by an examination of the hypogastrium, where the bladder, if full, will be easily detected. Any doubt as to the character of a central tumor above the pubes should lead to the passage of a catheter.

Atony of the bladder, if dependent upon some condition that can be relieved, may be recovered from. The chance of a favorable termination is, however, much more doubtful in old and worn-out subjects.

True paralysis may depend upon some nervous lesion (meningitis, apoplexy, syphilitic inflammation), which admits of more or less complete recovery. In the majority of cases the loss of power is permanent. The cystitis, however, which is its most uncomfortable accompaniment, may be kept under control by proper care.

The treatment in cases of paralysis and atony should consist, first, in the systematic use of a catheter. The bladder ought to be emptied at least as often as once in the twenty-four hours when the loss of power is partial, while in complete paralysis this should be done four or five times a day. In addition to this, irrigation should be regularly employed, especially when cystitis has already started. If the loss of power be partial, the washing may be done with cold solutions, which have a stimulating influence upon the detrusor muscle. Cold bathing of the abdomen and sacral region may similarly be of service.

Electricity is sometimes used with advantage. One electrode should be placed over the sacrum, and the other just above the symphysis pubis, in the perineum, or within the bladder itself.

Besides these local measures of treatment, the strength of the patient should be supported as far as possible by regulation of the diet, by exercise, and even by change of climate if it seem wise.

Strychnia and ergot are both thought to have a beneficial effect upon the muscular wall of the bladder; and general tonics are of use by their effect upon the general system.

When the power of retention is lost, a urinal becomes a necessity.

INFLAMMATION OF THE BLADDER (CYSTITIS).—This is the most common morbid affection of the bladder, and is the ordinary accompaniment of many other diseased conditions, such as calculus, tumors, etc.

The exciting causes of cystitis may be grouped under the following heads:

1. *Direct injury*, which may be the result of violence from without, often associated with fracture of the pelvis, and is also not infrequently caused by severe operations (lithotomy, obstetrical or gynæcological procedures). In child-birth the pressure of the head may alone suffice to set up cystitis. The long-continued pressure of a neighboring tumor or of the gravid, displaced uterus, is also to be mentioned here. The injury may, on the other hand, be received within the bladder from a stone or other foreign body, or from the introduction of instruments (catheters, lithotrites, etc.). The mechanical over-stretching of the bladder by too long retention of urine may be regarded as a direct injury, and occasionally causes cystitis.

2. *Irritation of urine altered by drugs or otherwise.* Of the drugs capable of setting up an inflammation when taken internally, may be mentioned cantharides, turpentine, cubebs, and copaiba. Stimulating injections are occasionally responsible by direct irritation. Acid concentrated urine is sometimes sufficiently irritating to cause a cystitis; especially is this the case if it contain minute crystals of uric acid, or oxalate of lime. The change in the urine, however, which most commonly causes inflammation of the bladder is the alkaline fermentation. This, like other fermentative processes, is due to the action of lower organisms (micrococci ureæ). The urea is decomposed and carbonate of ammonium is formed, and this extremely pungent, irritating salt is the active agent in producing cystitis. Ordinarily two conditions are necessary to bring about alkaline fermentation in the bladder. First, stagnation of urine, and secondly, the introduction of germs. Of these, the necessary condition is the last, without which fermentation cannot take place. Stagnation is, however, so important an adjunct, that in its absence the introduction of germs is often without effect. The reason of which is, that if the bladder thoroughly empties itself at each micturition, the germs are expelled before they have time to set up fermentation. If, however, any residue remains in the bladder, the micro-organisms propagate themselves in it, and the fermentation speedily takes place.

The most common method in which germs reach the bladder, is upon instruments which have not been thoroughly disinfected; but clean instruments may carry on into the bladder impurities which are present in the anterior part of the urethra, in the vagina, or upon the vulva. Lesions obstructive to micturition (stricture, enlarged prostate) act secondarily to favor fermentation, both by giving rise to residual urine, and by necessitating the use of instruments.

3. *Extension of inflammation from neighboring parts.* Cystitis due to extension of gonorrhœal inflammation from the urethra is usually confined to the region about the internal urethral opening (so-called neck of the bladder). This extension of inflammation may take place during the acute attack of gonorrhœa, and is usually to be referred to some indiscretion or want of care. Indulgence in alcoholic drinks, in sexual intercourse, in too much exercise—in short, anything which aggravates the urethral inflammation may precipitate an attack of cystitis. It should likewise be borne in mind that the chronic condition of inflammation of the deep urethra, frequently left as a sequel to gonorrhœa, is prone to sudden exacerbations. Many so-called idiopathic cases of cystitis are probably to be explained in this way.

Inflammations of the prostate, vagina, rectum, pelvis of the kidney, peritoneum, and pelvic cellular tissue, may also by direct extension implicate the bladder.

4. *Cystitis is very common in connection with diseases*

or injuries of the nervous system. In the majority of cases it is preceded by paralysis of the bladder, and is doubtless dependent upon the fermentation of the urine caused by its retention, and the consequent use of instruments. Its exceptionally rapid appearance, however, suggests the possible rôle played by the trophic nerves in its occurrence.

5. *Cystitis also appears as a complication in other diseases,* such as the eruptive fevers, puerperal fever, pyæmia, and septicæmia, typhoid, and variola. Its occurrence in connection with rheumatism is probably to be referred to the action of an exceptionally irritating urine. Cystitis is further often ascribed to the action of surface chill (catching cold). In a majority of the cases, however, thought to be due to this cause, there is some predisposing condition (latent inflammation in the deep urethra or prostate, etc.), which is lighted up by exposure.

Pathology.—The pathological appearances vary with the severity of the inflammation. In simple catarrhal cystitis, the mucous membrane is more or less swollen and reddened, with the minute vessels sometimes visibly injected. This redness is usually most marked on the summits of the folds or rugæ, which may be studded with punctate hæmorrhages if the inflammation has been of considerable intensity. Streaks of viscid mucus cover to a greater or less degree the inflamed surfaces. These appearances may be confined to the neighborhood of the urethral opening (partial catarrh, catarrh of the neck of the bladder), or may be diffused over the whole mucous membrane (universal catarrh). Even in this latter case, however, the evidences of inflammation are usually most marked about the urethra and trigone.

A loss of the superficial epithelium (erosion) sometimes occurs, and this is occasionally associated with the formation of false membrane (croupous inflammation). A severe inflammation sometimes leads to ulceration which may be diphtheritic in character. Rarely sloughing of considerable portions of the mucous membrane, and also of the muscular coat, follows long retention. When inflammation extends to the deeper layers of the bladder, the tissues are much thickened and infiltrated with pus, which may lead to the formation of abscesses. These may extend outward through the surrounding cellular tissue, and open spontaneously into the vagina, rectum, neighboring coil of intestine, or into the peritoneal cavity. Occasionally, however, they perforate the mucous membrane and open into the bladder itself.

When an opening is established between the bladder and a neighboring cavity, as the vagina or rectum, the constant escape of urine allows contraction of the bladder, and it becomes little more than a passage through which the urine escapes.

A long-standing chronic catarrh causes a brown or gray discoloration of the mucous membrane, often with considerable dilatation of the veins, especially about the urethral opening. The surface is covered with muco-pus which is often extremely viscid and adherent. The mucous membrane and parts beneath are much thickened and infiltrated. If an obstruction has been the primary cause of trouble, the muscular coat of the bladder is greatly hypertrophied and forms interlacing bands which stand out like the columnæ carneæ of the heart (vessie à colonne). At the same time that the bladder is thus thickened, it is often also dilated (eccentric hypertrophy). Little herniæ of the mucous membrane, between the fibres of the muscular coat, are not infrequent. Lastly, inflammation of the bladder may be tuberculous in character, in which case the mucous membrane of the bladder, the prostate, ureters, and even the pelves of the kidneys may be the seat of characteristic ulcerations.

Clinical History.—In cystitis the most prominent, almost unfailing, symptom is a *frequent desire to urinate.* This varies greatly in degree, from a slightly increased frequency of micturition which escapes notice, to an almost constant, painful tenesmus of the bladder, compelling constant straining efforts which only accomplish the voiding of a few drops at a time. This symptom is in no sense pathognomonic, as it is common to all affections which increase the irritability of the neck of the bladder. The sympton next in importance is *pain.* This may be very slight, and felt only just before and at the end of micturition. It may, however, be almost constant and severe in character. The pain is ordinarily referred either to the hypogastrium, the perineum, or the end of the penis, but when severe, assumes a lancinating character, shooting down the thighs, through the lumbar and sacral regions and to the testicles. Pain referred to the hypogastrium, especially if accompanied by tenderness in that region, is usually indicative of inflammation affecting the body of the bladder. When the neck of the bladder is the seat of intensest inflammation, the pain is referred to the perineum and to the end of the penis. These two prominent symptoms are usually accompanied by some *fever* in cases of acute universal cystitis. In inflammation of the neck of the bladder fever may be present, but is often slight or entirely wanting. In chronic cystitis there is ordinarily no febrile reaction. *Retention of urine* occurs rarely as a symptom ; it is most common in gonorrhœal cystitis, and, when it occurs, is evidence of considerable inflammation in the deep urethra, with often spasmodic contraction of the constrictor urethræ muscle.

Constipation is almost always present, and difficult movements of the bowels may greatly aggravate the pain in the bladder.

Cases of chronic cystitis, dependent upon conditions which cannot be removed, run a protracted course with many ups and downs. Errors in diet, exposure to cold, over-exercise, or any excess in alcoholic liquors or in sexual excitement, bring fresh accessions of inflammation, which are recovered from with ever-increasing difficulty, especially at an advanced age. Finally, some serious complication, such as inflammation of the pelvis and secreting portion of the kidney, ulceration, possibly diphtheritic, of the bladder wall, formation of an abscess, septicæmia or uræmia, appears and quickly closes the scene.

The character of the urine is of great importance in supplying information as to the condition of the bladder. In a mild case, the urine may be acid and but slightly cloudy. When the urine is allowed to stand for some time a light sediment separates, consisting of muco-pus, with usually a considerable number of flat epithelial cells. As the cystitis increases in severity, the urine becomes more and more turbid, from the increasing amount of pus, and in addition to the squamous surface epithelium, rounded cells, derived from the deeper layers of the bladder mucous membrane and from the neighborhood of the urethra, make their appearance. If, finally, alkaline fermentation occurs, the urine acquires a pungent ammoniacal smell, and the pus assumes a thick ropy consistency. Bacteria are also present in great number, giving a cloudy appearance to the urine even after the pus has settled out of it. Strongly ammoniacal urine causes the pus-cells to swell to several times their natural size, and finally to dissolve. Casts, if present, are similarly dissolved, a fact which should be borne in mind when examining for evidence of coincident kidney disease. Blood-corpuscles may be present in cases of cystitis of some severity, but in ammoniacal urine are quickly dissolved. The blood-pigment in this case imparts a brown or smoky color to the urine, which is quite characteristic.

Occasionally considerable quantities of blood may be passed and easily recognized. Besides these organized cells, many crystalline forms are found in the urine of cystitis. In strongly acid urine, crystals of uric acid or oxalate of lime are not infrequent. If they are in considerable quantity, and especially if of large size, they may be suspected, as the possible exciting cause of the inflammation. In ammoniacal urine, the crystals usually found are those of triple phosphate and urate of ammonia, with which are often associated amorphous phosphates in a fine granular form. If the bladder inflammation takes on a diphtheritic character, bits of discolored diphtheritic membrane may appear in the urine. Gangrene, or extensive gangrenous inflammation of the bladder wall, which is usually the result of severe injury, long-continued pressure, or of the breaking down of a new growth, gives the urine an excessively fetid character. The admixture of

blood, more or less decomposed, gives it a brownish, smoky, or green color, and the sediment contains much granular matter and large granular corpuscles, besides the various cells and crystals found in severe cystitis. Occasionally, especially as a result of long-continued pressure, considerable portions of the mucous membrane are thrown off, and may be recognized as such in the sediment. In the case of a sloughing new growth, characteristic forms (villi) can frequently be recognized under the microscope.

Hypertrophy of the bladder is a common accompaniment of cystitis. It appears in two forms, eccentric hypertrophy, or hypertrophy with dilatation, and concentric, or hypertrophy with contraction. If an obstruction to micturition is so great that the detrusor urinæ muscle is not of sufficient strength to empty the bladder, the gradually accumulating urine causes such a dilatation, that the bladder is to be felt as a tumor above the pubes, reaching often nearly to the umbilicus. Under these circumstances, micturition may take place regularly and in apparently sufficient quantity, but it is in fact merely an overflow, which leaves behind it a residuum of urine, the amount of which can be ascertained by the passage of a catheter immediately after micturition. Finally, when this condition of over-stretching has become so extreme as to deprive the bladder wall of its contractile power, the regular act of urination ceases almost entirely, and the urine trickles away constantly. This condition of overflow is sometimes called retention with incontinence, and is easily recognized by the presence of the full bladder above the pubes.

Concentric hypertrophy is brought about by the existence of some obstruction to the passage of the urine, with, at the same time, a condition of irritability which induces constant efforts at urination. The effect of this is a thickening of the muscular coat, with a diminution of the cavity of the bladder. This state of things may be recognized if an attempt be made to wash out the bladder, as the introduction of but a small quantity of fluid brings on an expulsive cramp, which not infrequently throws out the soft rubber catheter together with the water. The thick and hardened condition of the bladder wall is sometimes to be felt and appreciated by a rectal or vaginal examination.

Interstitial (parenchymatous) cystitis causes a train of symptoms much more severe than those occasioned by a simple catarrhal inflammation. There is ordinarily high fever, sometimes accompanied by chills. The inflammatory infiltration of the bladder walls stiffens them, and by hindering their contractions, makes complete expulsion of the urine impossible. The ureters, or the urethra, may be obstructed by abscesses, or by inflammatory swelling about their orifices. If an abscess breaks into the bladder, the appearance of a greatly increased quantity of pus in the urine is followed by a decided improvement in symptoms. If the opening takes place into the intestine, the symptoms also improve, although they may speedily resume their serious character if the intestinal contents get into and infect the abscess cavity. If the pus finds its way into the perivesical connective tissue, it may work outward and point either above the pubes or in the perineum, in which case its approach to the surface is heralded by preceding œdema and induration. Occasionally, perforation takes place into the peritoneal cavity, and speedy collapse and death is the consequence. Infiltration of urine is a very rare consequence of inflammatory rupture of the bladder wall. When it occurs, it causes usually an extensive œdema of the scrotum, perineum, and lower abdominal region. The skin over it quickly becomes dusky in color, and sloughing of the cellular tissue soon follows, accompanied by very grave symptoms of a low febrile character.

Diagnosis.—The diagnosis of a cystitis is usually a matter of tolerable ease, if the symptoms and the condition of the urine are carefully inquired into.

Pure neuroses of the neck of the bladder, which may cause similar subjective symptoms, do not cause the alterations in the urine which accompany inflammation.

Pyelitis, which also gives rise to pus in the urine, is to be distinguished by the existence of nephritic symptoms, and by the presence in the urine of pear-shaped cells from the pelvis, and, occasionally, of casts from the cortex of the kidney. Cystitis occurs, however, not uncommonly with pyelitis, so that the symptoms of the two diseases may complicate each other.

Urethritis is usually to be distinguished by the symptoms, and by the presence of a urethral discharge. Occasionally, however, an inflammation in the deep urethra may present features of similarity with cystitis. If, in such cases, the urine is passed in two portions, which are received in different vessels, the pus will be contained in the first part if the urethra alone be affected.

Cystitis of the neck of the bladder is to be distinguished from universal cystitis by the excessive character of the vesical tenesmus, as contrasted with the other symptoms, and by the presence of a few drops of blood squeezed out at the end of micturition.

Prostatitis resembles in many symptoms a partial cystitis. The pain of prostatitis is, however, referred to the rectum more than is the case in cystitis. The test of passing the urine in two portions reveals that the inflammation is anterior to the bladder, and, finally, palpation of the enlarged hot and tender prostate through the rectum completes the diagnosis. The coincidence of prostatitis with cystitis is not uncommon, and should always be considered.

The character of the urine gives, as has been shown, valuable information as to the severity and character of the inflammation. Croupous, diphtheritic, and gangrenous cystitis can generally be merely suspected, although shreds of tissue may sometimes be obtained and put the matter beyond doubt. Interstitial cystitis may sometimes be definitely made out when the posterior bladder wall is affected, and can be felt through the rectum. The bladder may even form a defined tender tumor, which can be felt from without. Usually, however, this condition can only be surmised from the history and the severity of the general symptoms. The formation and opening of an abscess would be confirmatory.

Prognosis.—Acute cystitis, when not dependent upon some previously existing chronic condition, runs a fairly short course, and with proper care, recovery may be looked for in from two to three weeks. The inflammation rarely reaches a severity to seriously threaten life. Chronic cystitis, if dependent on some curable condition (stone, stricture, etc.), may be recovered from after the removal of the exciting cause, provided that the long duration of the malady has not induced permanent organic changes in the bladder wall.

Advanced age and a weak constitution are extremely unfavorable to a hopeful prognosis. When the disease is the result of some condition which cannot be removed (enlarged prostate, tuberculosis, inoperable tumor, etc.), recovery cannot be expected, although a considerable amelioration of symptoms may be accomplished by appropriate and thorough treatment. The appearance of phlegmonous, diphtheritic, or gangrenous inflammation, with or without the formation of abscesses, or infiltration of urine, renders the prospect of recovery a matter of extreme doubt.

Prophylaxis.—Many cases of cystitis could no doubt be avoided by intelligent care. Careful management of an acute gonorrhœa, or of a stricture or enlarged prostate, would often enable the patient to escape the cystitis which they so frequently induce. The most important prophylactic measure, however—important because so constantly neglected—is a thorough observance of antiseptic precautions in any and all operative procedures upon the bladder. Thorough cleansing of instruments after use is not sufficient, they should be subjected to antiseptic treatment immediately before, as well as immediately after they are used. Especial care should be directed to cleaning out the space in the catheter below the eye, as this pocket, difficult to rinse out, frequently retains a little decomposing urine or mucus. It will be a fortunate day when catheters are habitually made without this dead space in the end. Other instruments (lithotrites, etc.) possess equally fatal cracks and crevices.

Lastly, an antiseptic lubricant must be selected which retains its antiseptic qualities for a considerable time. Glycerine is aseptic, but is a poor lubricant. Carbolized oil is unfortunately irritating to the urethra, and is not thoroughly aseptic (Koch). Eucalyptus-oil, combined with olive-oil, vaseline, or castor-oil, in the proportion of one part to twenty, is perhaps as satisfactory as anything.

Treatment.—In acute cystitis, whether universal or partial, the thing of first and greatest importance is rest. Rest should be absolute in bed, in a horizontal position, or with the hips slightly raised. The bladder, irritated and intolerant of its contents, should be soothed by full doses of some anodyne to lessen as much as possible its over-excitability, and to quiet its constant spasmodic activity. The anodyne is usually best administered in the form of a suppository, a favorite combination being opium or morphine, with either hyoscyamus or belladonna. Not infrequently, however, it will be found wise to give the anodyne by the mouth, as rectal absorption is slow and sometimes unsatisfactory. If the pain is due mainly to the spasmodic action of the bladder, hyoscyamus or belladonna sometimes suffices to relieve it, and when either of these is efficient it is preferable to opium, which is objectionable from its constipating properties, even when it does not disagree with the stomach. If, however, hyoscyamus or belladonna do not control the pain, opiates should at once be resorted to; and these should be given in full doses, as a really curative effect is to be expected from the relief of spasm.

Poultices or embrocations over the hypogastrium and perineum will often be of use, and, if well applied, will accomplish more than a hot hip-bath, which is commonly used, but which has only a transient effect. A hip-bath, if given, should be very hot, and the patient should be in it for but a few minutes (four to five at the outside), as the necessary position, if maintained for any length of time, favors congestion of the pelvic organs, and to a great extent counteracts the otherwise good effects of the heat.

To modify the urine and render it less irritating, water and demulcent drinks should be given in considerable quantities, and an alkaline diuretic usually renders valuable aid in this direction. Some salt of potash, notably the citrate, is usually chosen for this purpose. It may often be advantageously combined with a vegetable diuretic, buchu and triticum repens being, perhaps, the best of this class, although uva ursi, pareira brava, and others have deservedly some reputation. Buchu is best given in the form of an infusion, of which ℥ iv. to ℥ vj. should be administered *per diem*. A good combination is made by dissolving citrate of potash in the infusion, so that ℥ j. contains gr. xv. of the salt. This often does admirable service in quieting irritability of the bladder. Triticum repens may be given in the form of fluid extract, or as a decoction, of which a pint should be taken in the course of the twenty-four hours.

Besides this strictly medicinal treatment, the diet should be carefully regulated, only bland, unirritating articles of food being allowed. Alcohol, in every form, should be interdicted, and tea and coffee should be avoided, or taken very much diluted. The bowels are to be kept gently open, and especial care in this direction is needed when opiates are being used.

While the inflammatory process is being combated in this manner, the exciting cause of the cystitis should be sought for and, if possible, removed. If an irritating diuretic is being taken it should be stopped. A rheumatic or other constitutional cause, should receive appropriate treatment. Retention of urine, if it exists, should be relieved by the use of a catheter. When, however, the cause of the cystitis is one which requires an operation for its removal (calculus, stricture, etc.), it is usually best, unless in case of emergency, to defer interference until the acute stage of the disease is past.

If the inflammation is so severe as to involve surrounding parts, and to give rise to pericystitis, the appearance of abscesses must be watched for with great care, as their early detection and evacuation is of cardinal importance.

Ordinarily an acute cystitis yields to careful treatment, and recovery is complete. If, however, owing to neglect, or to the existence of some unrelieved cause, the attack does not quickly pass off, but continues in a chronic form, other measures of treatment must be adopted. If a calculus or tumor exists, it must be removed; a stricture must be dilated; retained urine dependent upon enlarged prostate, hernia, atony, or paralysis, must be systematically drawn off.

Almost all cases of subacute or chronic cystitis, especially when associated with foul, decomposing urine, are to be greatly benefited by thorough irrigation; and this measure may even be employed in acute cases if the urine assumes a fetid character.

When properly performed this washing out of the bladder usually does much good, but if done carelessly or improperly it may cause serious harm.

Sir Henry Thompson directs that no more than two ounces of fluid shall be thrown into the bladder at one time. This rule is a good one in cases of acute cystitis, or when the bladder is greatly contracted or especially irritable. In many chronic cases, however, it is not only safe, but wise, to somewhat distend the bladder with the injected fluid, the object being to spread out the folds of the mucous membrane so as to insure the thorough removal of fermenting mucus and the contact of the irrigating fluid with all parts of the bladder wall. If the injection is made slowly, the bladder ordinarily tolerates the distention well.

With regard to the injecting apparatus, a syringe forces the fluid in with irregular, intermittent force, and imperfections in the valves make it often a matter of uncertainty whether the proper amount has flowed into the bladder or not. These disadvantages are avoided by the use of a fountain-syringe, and if a clear glass bottle is used as the reservoir, it can be easily kept clean, and the exact amount of the fluid which flows into the bladder can be readily seen and exactly measured by a scale fastened upon the side of the bottle. The force of the stream is to be regulated by adjusting the height of the reservoir above the bladder. This should never be greater than from one to two feet, or the bladder may be subjected to a dangerous strain. It is also important to stop injecting the moment the patient feels the least desire to micturate.

The simplicity of this apparatus is of great advantage in point of cleanliness, and patients quickly learn to manage it for themselves.

The catheter used should be of soft rubber, if such can be introduced; if not, that form which passes with least irritation is the best, whether bulb-pointed or *coudée*, gum-elastic (English) or silver. A double-current catheter is less good than one with single calibre, for the continuous stream does not cleanse the bladder so quickly as is done by alternate filling and emptying, and the necessarily small size of the escape-tube in a double instrument prevents the ready exit of thick pus or mucus. Many drugs are added to the injection-fluid, either with the object of disinfecting the contents of the bladder or of acting topically upon the mucous membrane. A few of the most serviceable mixtures may be mentioned.

For disinfecting purposes, to correct foul, decomposing urine, carbolic acid may be used in a one-fifth to one-half per cent. solution; corrosive sublimate in a one two-hundredth per cent. solution; boracic acid in a one to two per cent. solution; phenyle in a one-fifth per cent. solution. The addition of a teaspoonful of glycerine to every four ounces of the solution renders the antiseptic less irritating. As a soothing application, with slight antiseptic action, borax (biborate of soda) is often used in a three to five per cent. solution. This is perhaps the most generally useful mixture for bladder irrigation, and may always be employed, unless there is some decided indication for another drug. Chlorate of potash is sometimes used with advantage in a one to three per cent. solution.

Occasionally, when the secretion of pus or mucus is very abundant, astringents are required, and zinc sulphate in a one-tenth to one per cent. solution, acetate of lead in a one-twentieth to one-tenth per cent. solution, or per-

manganate of potash in a one-tenth to three-tenths per cent. solution may be employed.

In phosphaturia very dilute hydrochloric or nitric acid (one or two drops of strong acid to the fluid ounce of water) may assist by their solvent and astringent action.

Lastly, we come to speak of nitrate of silver, which, if properly used, is productive of much good, but if abused or improperly employed may do decided harm.

An obstinate chronic cystitis which does not yield to milder measures is sometimes greatly benefited by the use of a weak solution (one-tenth to one-fifth per cent.) of nitrate of silver. This gives the best results when it is used every second or third day, some milder injection being substituted on the intermediate days. The amount of pus is usually very decidedly diminished by these applications.

Occasionally, it happens that adhesive mucus so clogs the eye of the catheter as to prevent the escape of the urine. This may be removed by attaching a rubber tube full of water to the catheter and then dropping its free end into a vessel upon the floor. The weight of this column of water usually exerts sufficient suction to draw out the obstructing mucus.

In chronic cystitis, the local treatment is more to be relied upon than medication. Some remedies, however, have a decided power to modify the course of the disease.

Of these, besides the vegetable and alkaline diuretics spoken of in connection with acute cystitis, we may mention benzoate of soda and benzoate of ammonia, both of which have the property of correcting undue alkalinity of the urine, and of arresting fermentation. Dose of either, from five to twenty grains, t.i.d. Eucalyptus has a similar power of modifying fermentation, and its efficiency is highly praised by Bartholow. Diuretics of a stimulating character, such as copaiba, cubebs, turpentine, and cantharides, are used with occasional good effect in inveterate chronic cystitis, but they are uncertain in their action and may do harm.

In the majority of cases the measures that have been suggested will accomplish, if not a cure, at least a palliation of symptoms which brings comparative comfort to the patient; occasionally, however, a case is met with in which the bladder has suffered such decided organic changes that the passage of the urine through it, with its alternations of expansion and contraction, is sufficient to keep up an aggravated inflammation. In spite of every care the patient begins to suffer from hectic, and death seems imminent.

Under such circumstances cystotomy holds out a last hope. An opening through the perineum, by providing drainage and rest to the bladder, allows it time and opportunity to recover itself. This treatment was first applied to a case of this sort by the late Dr. Willard Parker, of New York, in the year 1850.

The necessary opening may be made either laterally through the prostate, as in lithotomy, or may enter the membranous urethra through the middle line, and through this opening the prostatic urethra may be readily dilated with the finger so as to admit the introduction of a good-sized tube. The latter method has the advantage of injuring no important structures, whereas the former promotes more thorough drainage. Whenever an incision through the perineum is practised it should be made the opportunity for a thorough exploration of the bladder, as an unsuspected cause for the cystitis may sometimes be found.

Stone in the Bladder.—The stones which are commonly found in the bladder may be roughly divided into uric acid, oxalate of lime, and phosphatic calculi. A stone composed wholly of any one of these constituents is, however, not common, the usual condition being a mixed form, in which a uric acid or oxalate of lime nucleus is covered by a phosphatic crust; sometimes a succession of layers may be formed by alternating deposits of different components. The phosphates are almost always combined with alkaline urates and carbonates. Other substances, such as cystin and xanthin, in rare instances form concretions in the bladder.

For purposes of surgical classification, calculi may be divided into those which form in an acid, and those which form in an alkaline urine. The former class includes the uric acid and oxalate of lime stones, while the soft concretions, composed mainly of phosphates, belong to the latter.

The formation of calculi in acid urine is dependent upon some disturbance of the general system which leads to the too great excretion of solids, which are deposited out of the urine before it is voided. On the other hand, it is a matter of the rarest occurrence for urine to be excreted with such an excess of alkaline constituents as to cause their separation in the form of a concretion.

The formation of phosphatic stones is almost invariably the result of inflammatory conditions in the urinary tract, leading to alkaline fermentation of the urine.

Calculi may form in any part of the urinary apparatus. When they originate in the kidney they usually find their way, sooner or later, into the bladder. This may be accomplished painlessly, or may be accompanied by severe pain (nephritic colic).

After reaching the bladder they either pass out through the urethra and cause no further trouble, or they remain and gradually increase in size, until their presence is revealed by the symptoms they give rise to. Their detention in the bladder is rendered extremely probable when some obstruction to micturition has caused dilatation with residual urine, or when sacculation of the bladder exists. A stone thus retained in the bladder continually grows by accretion. So long as the urine remains unchanged, the character of the stone continues the same; when, however, the urine, formerly acid, becomes alkaline from the occurrence of fermentation, the soft salts (phosphates, etc.) are deposited on the hard basis of calcic oxalate, or uric acid.

Stones usually occur singly, but sometimes many, up to several hundreds, are found in one bladder.

Single calculi are moulded into a more or less oval form by attrition of the vesical walls. The surface may be tolerably smooth, as is often the case with uric acid calculi, or rough and granulated, as is more commonly seen in phosphatic stones; and finally, those composed of oxalate of lime are usually covered with rough, often sharp projections, giving them a knobby, irregular outline, which has suggested their distinctive name of mulberry calculi.

When many calculi exist together in the bladder, they are usually smoothed and faceted by mutual attrition.

Stones vary greatly in size and consistency. Very large concretions were much more common formerly than now, when they come earlier to operation.

Phosphatic stones are usually soft and friable, though they may sometimes have considerable hardness. Uric acid makes firmer calculi, which are, however, tolerably brittle. The hardest stones are those made of oxalate of lime, and they may occasionally resist any but the most powerful lithotrites.

Stone in the bladder is often hereditary. A gouty or rheumatic diathesis, by favoring the production of acid urine, fosters the tendency to stone.

The habitual use of liquids or articles of food that easily ferment and give rise to acidity may increase the chances of stone formation. That the quality of the drinking-water (presence of lime salts) has any influence is not proved.

The geographical distribution of stone seems to be independent of any climatic or geologic influences.

Dr. Keyes believes that the prevalence of stone in certain localities is to be in great measure accounted for by the hereditary nature of calculous disease, fostered by more or less close intermarriage.

Thompson states that stone is common in the children of the poor, but rare among old persons; whereas among the rich this state of things is reversed and the children are exempt, while their elders are oftener afflicted.

Symptoms.—The symptoms of stone in the bladder are: First, *pain*. This is especially severe at the end of micturition, when the bladder wall closes down upon the rough surface of the calculus. The pain is referred either to the end of the penis, or to the perineum and rectum. It is

usually much increased by violent movements or jolting, as in riding. Secondly, *frequency of micturition*, which may or may not be diminished by rest in bed. Thirdly, *hæmaturia*. The presence of blood in the urine is intermittent. The water may be of a wine-red or smoky color, or the blood may be contained in the last few drops of urine passed. Hæmorrhage is likely to appear after exercise or jolting. When these important symptoms are present, inquiry will often discover a history of previous attacks of renal colic, or of the appearance of gravel in the urine.

As confirmatory symptoms may be mentioned, sudden stoppage of the stream in the midst of micturition, caused by the stone falling against the urethral opening, and in children an elongated prepuce, owing to constant pulling in the effort to relieve pain felt at the head of the penis.

A bimanual examination between the hand over the pubes and the finger in the rectum will often reveal the presence of a stone of any size.

The diagnosis is rendered complete by a thorough exploration of the bladder with a sound. For this purpose a metallic instrument should be used, with a short beak curved to an angle of about 135°, which, by allowing freedom of motion in the bladder, makes a much more thorough examination possible than with an ordinary curved catheter. Sometimes a stone that evades the sound may be caught in a lithotrite, and its presence thus demonstrated. The lithotrite also affords the most accurate method of determining the size of a stone; and by dropping and seizing it again several times the dimensions may be measured in several diameters. When a stone is caught in the lithotrite, it should be firmly held, and the instrument with the stone in it should then be used for a further search, to determine whether more than one stone be present.

It is well during an exploration, especially in a difficult case, to vary the amount of water in the bladder, as a concretion, difficult of detection in a full bladder, may be easily found in an empty one, and *vice versa*.

Occasionally it happens that in a sacculated or otherwise misshapen bladder a calculus will evade detection by most thorough and skilful sounding. For these cases Professor Bigelow has pointed out the value of the litholapaxy pump and tube. The current of water searches out and brings the calculus to the tube with a characteristic click which cannot be mistaken or overlooked.

Examination by the sound may be rendered difficult by stricture of the urethra, which, if not passable for an instrument of fair size, will require dilatation, divulsion, or division with the urethrotome.

Enlarged prostate may greatly increase the difficulties of sounding, both by the resistance it offers to the entrance of the instrument, and by reason of the sacculation of the bladder behind the prostate in which the stone may escape detection. This source of error is usually to be avoided if a sound with a short beak be used and so rotated that the point sweeps the base of the bladder. To accomplish this manœuvre the handle of the sound or searcher must be well depressed between the thighs, as otherwise its point catches on the floor of the bladder. The finger in the rectum may materially assist in this investigation. A bar at the internal urethral orifice may cause difficulties similar to those incident to an enlarged prostate.

Sacs and diverticula of the bladder occasionally make the detection of a stone by the sound alone very difficult, though often a careful search will finally carry the instrument into contact with some part of the calculus.

Extreme sensitiveness will often make an examination impossible without the aid of an anæsthetic.

The sources of error which must be considered in sounding are prostatic concretions, rough projections of the bladder-wall, which may be covered with phosphatic deposits, and new growths which may be similarly encrusted.

A practised touch will usually lead to a decision between these conditions. The grating over a prostatic concretion is felt before the bladder is reached, and in a case in which the doutbtful sensation is felt within the bladder, a conclusion may usually be reached by the passage of a lithotrite and grasping of the stone if one exists.

Prophylaxis.—Soft phosphatic stones are, as has been said, dependent usually upon a local condition of inflammation of the bladder, and any treatment, by irrigation or otherwise, which reduces this inflammation, lessens the chances of stone formation. Uric acid and oxalate of lime-stones, on the other hand, are of constitutional origin, and indicate faults of assimilation and tissue-change which are, in a degree, amenable to constitutional treatment.

When a tendency to uric acid formation is evinced by the appearance of crystals in the urine, or by any symptoms indicating a gouty diathesis, efforts should be made to counteract this tendency by strict attention to the patient's habits with regard to food and exercise. Sugar in every form is harmful in these cases, as are also all fatty articles of food, and these should accordingly be avoided. Over-indulgence in stimulating highly seasoned dishes should be interdicted. Wine should be given up, and if the stimulant effect is needed, spirits, largely diluted, should be preferred. Systematic exercise should be taken; if possible sufficiently violent to excite moderate perspiration, and the skin should be cared for by regular bathing and vigorous rubbing. If the patient be constipated his bowels should be regulated, and this may well be done by a morning glass of Friedrichshall or Carlsbad water. Thompson recommends a long course of saline waters for these patients with uric acid tendencies, and regards their effect as due to a stimulant action on the liver. Whatever the *rationale* of their use, they are of undoubted benefit when a constipated habit exists.

Lastly, general tonics, such as strychnine and quinine, may be of great service when the general health is debilitated. Alkaline diuretics by correcting the overacidity of the urine relieve local symptoms; but without the addition of general treatment the acidity returns quickly upon their disuse.

Treatment.—After the formation of a stone too large to pass through the urethra, its removal can only be accomplished by some mechanical expedient, The solvent action of alkaline or other remedies has never been shown to destroy a stone that had been proved to exist.

The choice of the operation appropriate to each case is to be decided both by the character of the stone and by the condition of the urinary organs.

In children the small size of the urethra makes the use of crushing instruments both difficult and dangerous, and as children usually do well after lithotomy (mortality about six per cent.) this operation is to be preferred for them.

After puberty, the urethra soon attains a size sufficient to allow the use of instruments, and the treatment is then to be selected according to the rules which hold in adults.

The crushing of stone—lithotrity—became a recognized operation in 1824, through the efforts of Civiale, who, although operating with inferior instruments, obtained successes which demonstrated the possibility of pulverizing stones with instruments introduced through the urethra.

After that time the operation was greatly improved in technique, and largely displaced the earlier operation of lithotomy. (For the history of its development, see under the head of Lithotrity.)

In 1879 Professor Henry J. Bigelow published a paper introducing the operation of litholapaxy (lithotrity at one sitting, rapid lithotrity), and so quickly did this procedure gain in favor, that within a year or two of the publication of his first article, it was a generally established practice; and the old operation of lithotrity, without complete evacuation, had become a thing of the past.

Professor Bigelow showed that the tolerance of the bladder to instrumentation is much greater than had been supposed, and demonstrated the fact that there is less danger in an operation, even long and tedious, which results in the complete evacuation of a stone, than in the usual short and repeated sittings for its more gradual removal.

In short, he proved that the greatest danger of lithotrity is not from the use of instruments, but from the subsequent irritation of the mucous membrane by the fragments left in the bladder. To facilitate the rapid crushing and removal of stones, he also introduced improved instruments, which will be described under the head of Litholapaxy.

With these instruments it is now possible to dispose of many stones that would formerly have been thought beyond the reach of lithotrity, and it suffices to say that litholapaxy should be employed in all adult stone-patients, except in cases falling under the following exceptions:

1. A very large and hard stone may resist every attempt at crushing.
2. A stone may have as a nucleus a foreign body, such as a piece of necrosed bone or a bullet, too hard to crush, and too large to come through a tube.
3. An encysted stone may be out of reach of the lithotrite.
4. Some writers consider that stricture of the urethra may prohibit litholapaxy. This cannot often happen, for strictures, however close, yield readily to divulsion, which may be immediately followed by the crushing and evacuation of the stone. I have so often seen these two operations successfully done together upon an etherized patient, that I can but think this the best practice. While it economizes time, it saves the patient much needless manipulation.
5. False passages may exist, which so interfere with the introduction of instruments, that the dangers of the operation are greatly enhanced, and the question of lithotomy is to be entertained.
6. The hip may be anchylosed, in a position which interferes with the use of instruments.

In any of these exceptional cases, a cutting operation may be required, and a consideration of the various methods of performing such operations will be found under the head of Lithotomy. *Arthur T. Cabot.*

BLADDER AND URETHRA OF THE FEMALE. The bladder and urethra of woman are subject to all the diseases and other abnormal conditions observed in the male. Hence these parts are the subject of inflammations, of tumors, benign and malignant, and of displacements. Calculi and foreign bodies are not rarely found in the bladder of woman. That adjacent organ, the uterus, with its frequent changes of size, and its numerous perturbations from the performance of natural functions, entails on the bladder much irritation and disease. There are, therefore, numerous peculiarities which demand a special consideration of disease and abnormality as they occur in the female bladder and urethra.

Malformations of Bladder and Urethra.—These conditions, though rare, are occasionally met with. They are easy enough of explanation if the mode of development of the parts be considered. The urethra may be absent entirely or in part. Partial absence may be of either the internal or external portion. The parts may be in a condition of complete closure or atresia. A case of malformation, which recently presented itself to the writer, will be of interest. The patient, an unmarried woman, of twenty-five, came to the University Dispensary for Diseases of Women, complaining of incontinence of urine of a few months' duration. There were no evidences of present or past pregnancy, but a history of amenorrhœa for a few months. The vagina and uterus were normal. At the site of the urethra, between the pubes and anterior vaginal wall, was a wide pit or cloaca, the edges of which were abraded, but not ulcerated. At the bottom of this was an opening leading directly into the bladder. This opening was bounded by a cockscomb-like fringe which afforded to the woman partial retentive power. She was evidently of loose habits, and the explanation which suggested itself was that by accident, during sexual intercourse, the male organ had entered the bladder. This would account for the acquired incontinence which she asserted most positively to be of only a few months' duration. This incontinence of urine was not complete, but existed only in the upright position. Complete atresia of the urethra is a rare condition, observed, of course, at the birth of the child. Such children are usually born dead. The result is enormous distention of the belly, due to distention of bladder, ureters, and kidney. The abdominal enlargement may be sufficient to interfere with delivery. The most frequent anomaly of the bladder is a defect of the anterior wall, which is absent to a greater or less extent. It is associated with defective development of adjacent organs and parts. Both umbilicus and anus lie nearer to the symphysis pubis than usual. In the slighter forms it is merely a fissure or small opening. Or the genitals, urethra, lower part of the abdominal wall, and symphysis pubis may be normally developed, and the defect consist in absence of the anterior vesical wall above, near the level of the umbilicus; or from persistence of the urachus, urine may escape by a variable-sized opening at the umbilicus. The most extreme degree is that in which the whole anterior wall of the bladder is wanting, and the cleft space of the abdominal wall is occupied by a projecting exuberant red mass, the *mucosa*, and other coats of the posterior wall. It is wrinkled, thickened, puckered at the edges and shades into the integument at the margin. At the lower border, the orifices of the ureters are easily recognized by the visible escape of urine. They are, indeed, sometimes much dilated and may contain calculi. In this form the symphysis pubis is absent, the pubic bones being connected by fibrous bands. The urethra is entirely absent. The clitoris is widely cleft, the labia entirely absent or imperfectly developed and separated. The writer was recently consulted for such a case, similar in every particular to that just described. The object was to ascertain if by a surgical operation marriage might be rendered feasible. The most important malformations are the result of retention of urine from atresia or absence of the urethra, or from accumulations of fluid in the allantois preventing the closure of the ventral fissure.

The symptoms are involuntary escape of urine and the inconvenience arising from the sensitive vulnerable tumor. Although the life of infants is endangered by this condition, many survive and attain a good age.

The prognosis is unfavorable. Operative treatment does not promise much. It often fails entirely. The indications are to replace the protruding posterior wall, and to cover it by large flaps dissected from the abdominal wall on either side, inverting them, epidermis inward, and uniting them with sutures over the middle line. A urethra may be formed on a similar principle, but inasmuch as a sphincter cannot be formed, the patient does not acquire retentive power. Flaps thus formed contract exceedingly. They must, therefore, be made very much larger than the surface to be covered. In successful cases, the bladder is enclosed, and prolapse of the wall prevented. The cavity of the bladder may increase, and, if a urethra be formed, it may be closed temporarily with some kind of clamp, or, short of this, the possibility of adapting some kind of receptacle is greatly increased. In the slight form, in which only a fistula of the urachus exists, the urethra being perfect, the prognosis is good. There is little difficulty in closing the upper opening. Another, much rarer malformation, is the double bladder. A vertical septum divides the organ into two chambers. The catheter might diagnose the condition, but the finger, after dilatation of the urethra, would be much more certain.

Before proceeding to describe diseased conditions of the urethra, it will be well to speak of the methods of examination of that canal. The female urethra may be examined:

1. By the sound.
2. By the speculum, of which various forms have

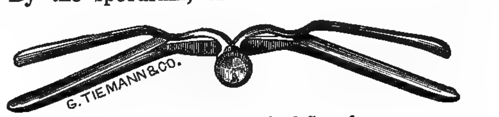


Fig. 405.—Skene's Urethral Speculum.

been devised. Emmet uses a miniature Sims' speculum. Skene has devised an instrument somewhat resembling a Sims' speculum, but with a depressor attached (Fig. 405).

He has also modified Folsom's nasal speculum for the same purpose. The same authority has devised an endoscope-speculum, which he claims to have found invaluable in the investigation of bladder and urethral disease in women. The following is his description: "This instrument is composed of three parts. A glass tube (*a*, Fig. 407, 2) is shaped like the ordinary test-tube used by chemists, except that the mouth is a little more flaring. The second part (*b*, Fig. 407, 2) is composed of two pieces, a mirror and the arrangement which holds it. A piece of very thin silver plate is made to fit nearly the whole length of the inside of the glass tube, and over about one-third of its circumference. To one end of this arrangement the mirror is attached at an angle of about one hundred degrees. At the other end a delicate handle projects at an obtuse angle. This part of the instrument looks like a section of a tube that has been divided into three equal parts by longitudinal section, with a mirror attached at one end, and a handle at the other. This piece is made perfectly black on the inside, and answers two purposes—it holds the mirror, and when placed in position for use darkens one side of the glass tube. It will be seen that the mirror can be moved forward or backward, and turned around, so that when the tube is introduced into the urethra or bladder, the exposed internal surfaces can be brought into view by moving the mirror while the tube remains stationary. Fig. 407, 1, shows the glass tube placed inside of a fenestrated hard-rubber speculum; and Fig 407, 3, shows the glass tube inside of a speculum that is open and bevelled at the end. These specula are used in making applications to the urethra and bladder. . . .

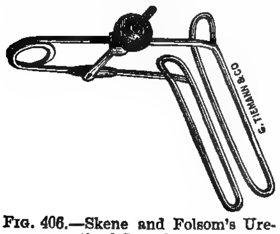


Fig. 406.—Skene and Folsom's Urethral Speculum.

"The method of using this instrument is as follows: The tube, with the mirror inside, is introduced into the urethra, and bladder also, if an examination of the latter be desired. Light is then thrown into the tube by the aid of a concave mirror; this shows that portion of the interior of the urethra or bladder which is opposite the

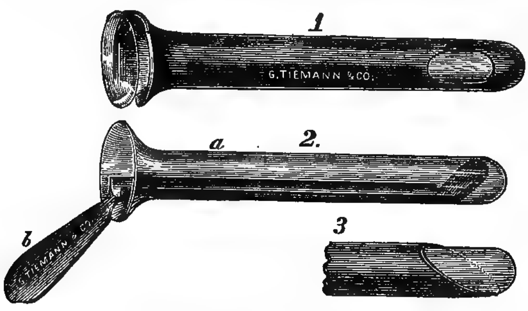


Fig. 407.—Skene's Endoscope-Speculum.

mirror, and by moving the mirror backward and forward the whole of the parts to be examined are brought to view in regular succession."[1] Sunlight, or a good lamp, may be used.

3. By dilatation of the urethra. This operation will be described in a subsequent part of this article in connection with the diseases in the treatment of which it is found useful.

4. By Emmet's button-hole incision of the urethra. For this operation etherization of the patient is necessary. She is then placed in Sims' position, and a Sims' speculum introduced to expose the vaginal aspect of the urethra. For making the incision, Dr. Emmet has devised an instrument on the principle of the button-hole scissors. The part which enters the urethra is round, like a sound; the vaginal blade has a portion removed, so as to begin the incision about a quarter of an inch from the outer orifice of the urethra. The incision is then extended back nearly, but not quite, to the vesical end of the urethra. If the latter were included, incontinence of urine would be the result, and this must be avoided. The knife or scissors may be used. In the latter case, a full-sized curved sound is to be first passed into the urethra, and there held. With a tenaculum the tissues on the vaginal surface are caught up and steadied, while an incision is made down to the sound. The incision is then extended with straight pointed scissors. The line on the vaginal aspect must be nearly one-third longer than that through the urethral *mucosa*. The finger, or a small speculum, can now be easily passed into the bladder without fear of the patient losing retentive power.

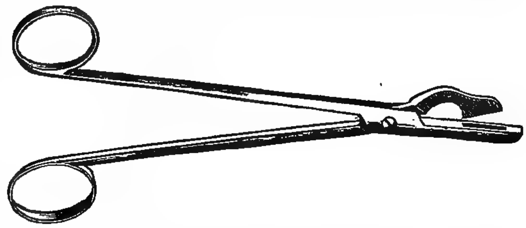


Fig. 408.—Emmet's Scissors for Button-hole Operation of the Urethra.

If the object be merely exploration of the canal and no ulterior one of treatment, the opening is to be immediately closed by sutures. If desirable to allow the opening to remain for after-treatment, then the edges of the vaginal and urethral *mucosa* are to be united with sutures. The after-treatment consists of large hot-water vaginal injections twice daily, followed by application of carbonate of zinc ointment. The next cut illustrates the appearances of the completed operation.

When, after a few months, a cure of the diseased condition has been effected, the opening is to be closed by paring the edges and suturing them.

Anomalies of Form and Position of the Urethra. General Dilatation is most commonly produced by the male organ, in coitus, in cases of imperforate hymen or narrow vagina. Other causes are spontaneous expulsion of calculi, or the extrusion of tu-

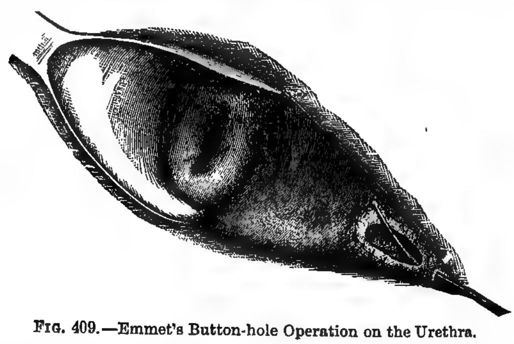


Fig. 409.—Emmet's Button-hole Operation on the Urethra.

mors of the bladder or of the bladder-coats, a process of inversion. In this condition the parts concerned may or may not be inflamed or abraded, ulcerated, or fissured. It is somewhat remarkable that incontinence of urine has not existed in the majority of such cases. The *mucosa* of the whole circumference of the urethra may undergo a process of dilatation or hypertrophy, and be extruded from the outer end of the canal. This obstructs the flow of urine and excites tenesmus of the bladder, which, in turn, aggravates the original condition. "Ultimately," says Emmet, "the whole urethral canal becomes displaced and pressed forward, or rolled out by a prolapse of the superabundant tissue at the neck of the bladder."

Treatment.—In general dilatation there are sometimes no symptoms, and then treatment is unnecessary. When

the condition is due to coitus, the patient consults a physician because of sterility, when, on examination, the true nature of the case becomes apparent. It is far otherwise when incontinence of urine results. Here the plight of the patient is indeed sad. For the relief of the condition cauterizations of the whole, or a part of the membrane, have been practised with varying success. Chromic acid and nitrate of silver have been used with success; so also astringent injections of tannin or sulphate of copper. The astringent selected may be applied in the form of a bougie made with gelatine.

PARTIAL DILATATION.—Urethrocele or diverticulum urethræ affects the posterior wall a few millimetres above the orifice. It is to be diagnosed by passing a sound or catheter into the urethra. It sinks into a cavity or pouch. The little finger coaxed into the urethra more certainly diagnoses the condition. The symptoms are painful micturition and involuntary escape of urine. The urethra becomes inflamed from retention of a small quantity of urine, which becomes stale. Treatment consists in excising an oval-shaped portion of the whole thickness of the urethro-vaginal wall. The edges are then brought together with sutures.

STRICTURE of the female urethra is much rarer than the conditions just mentioned. The principal causes are injuries to the urethro-vaginal septum, as in difficult labors, gangrenous vaginitis, and urethral chancre. Each of these causes operates by cicatricial contraction. A rarer cause is to be found in tumor of the urethra. In vesico-vaginal fistula the urine all escapes by the unnatural opening, and the urethra contracts.

Symptoms.—Diminution of the size of the stream, or escape of urine *guttatim;* ultimately vesical catarrh, hypertrophy of the coats of the bladder, and prolapsus of vaginal walls from repeated straining. *Treatment* consists in hot water vaginal douches, and the use of graduated bougies or catheters. The patient must be warned of the tendency to relapse and of the importance of early return for treatment. For this condition (stricture), which he finds to be very rare, Dr. Emmet asserts that it is necessary to perform his button-hole operation directly over the stricture, and after the parts have healed, to reform the urethra to the extent of the normal urethra, which he claims may be easily done.

DISPLACEMENTS OF THE URETHRA.—The displacement may be in almost any direction, but the most important is a prolapse of the *mucosa* and tissue underlying it. The part thus displaced appears at the orifice as a reddish swelling. It may proceed from the upper or lower part of the canal or involve its whole circumference. The most common cause is labor. The loose movable tissues are forced down by the advancing head of the child. The symptoms are obstruction to the flow of urine and tenesmus of the bladder. The straining increases in its turn the prolapsus. Ultimately, the coats of the bladder near its neck may roll out through the dilating urethra. The pressure causes œdema of the tissues, cystitis results speedily, and ultimately disease of the kidneys ensues. Treatment is surgical. The prolapsed part is to be removed. If it affect the anterior wall of the urethra near the orifice, it is to be gently drawn out, secured by a double ligature in two sections, and the parts cut off. When the whole circumference of the urethral lining is prolapsed, the treatment just described will not apply, else stricture of the urethra must result from the inevitable contraction of the raw surface left. Emmet treats such cases in the following manner: An opening is to be made in the base of the bladder, to let the urine drain off as fast as it reaches the organ. This gives complete rest to the bladder and hypertrophied tissues of the urethra. The prolapsed tissues are to be returned within the bladder, by passing a full-sized steel sound. It is then removed by a rotatory movement, while the fingers make firm pressure upward and backward, along the urethra. This is to be repeated from time to time, and, after each application, Churchill's solution of iodine is to be applied, to make the tissues shrink. This can be well done through a conical ear-speculum, introduced as close to the neck of the bladder as possible. After the urethra has been restored to its normal condition, the vesico-vaginal fistula may be closed. For the immediate removal of the excess of tissue Emmet has devised the following operation:[2] The patient being placed in Sims' position, and a Sims' speculum introduced, a large-sized polished sound is passed into the urethra, and held by an assistant. An incision, about three-fourths of an inch in length, is made on the vaginal surface of the canal. This incision must not involve either extremity of the urethra. In depth, it extends nearly, but not quite through to the sound, which, however, ought to be seen shining through. The loose membrane is then caught by a tenaculum and pulled through, until all the excess is thus removed from the urethra. The opening is then closed with sutures, which transfix and engage the loose membrane, lying between the edges of the wound. The excess of tissue is now cut off, and the sutures secured. Union takes place with tolerable certainty, and results in permanent adhesion of the lining membrane along the line of sutures. Such an operation cures the patient, if the original cause of straining, which led to the extrusion of the urethral and vesical *mucosa*, be removed. Such cause may be a cystitis, fissure at the neck of the bladder, fissure of the anus, etc.

Downward displacement of the whole urethra occurs as a part of the protruded structures in cystocele, and in procidentia uteri et vaginæ. Its treatment is involved

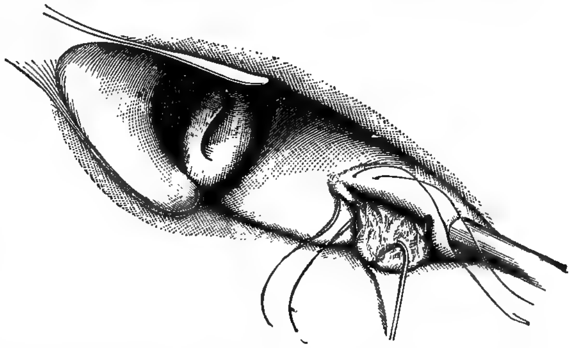


FIG. 410.—Operation for Radical Cure of Prolapsus of Urethral Mucosa. (From Emmet.)

in that of these conditions. Upward displacement occurs as a result of the upward dragging of tumors, and sometimes during pregnancy. It may not be treated as a separate lesion.

URETHRITIS.—It may be acute or chronic, with or without hypertrophy and ulceration. These conditions may be due to causes inherent in the constitutional state of the woman. Unhealthy urine, as when it is concentrated, ammoniacal, bacterial, or containing fragments of diphtheritic membrane or blood, is often the cause. Diseases of the kidneys and bladder, therefore, often inflame the urethra. Urethritis often results from extension of inflammations, simple or specific (gonorrhœa), of the vulva and vagina or cervix uteri. It is a by no means rare complication of the specific fevers, small-pox, scarlet fever, typhus, measles, etc. Mechanical causes are labor, natural as well as instrumental; coitus; the introduction of the catheter and sound; falls or kicks on the part; and the introduction of foreign bodies, so often practised by hysterical, prurient, and insane women. The symptoms are, deep red color, swelling and secretion of the *mucosa*, and in the severer forms itching or smarting, and scalding micturition. The discharge is at first mucus, and later contains an admixture of pus or blood. A number of red points about the orifice of the urethra indicate the openings of follicles, not previously conspicuous, into which the inflammation has extended. Among these, the glands described by Skene,[3] on the floor of the urethra, are notable. Ordinarily their openings are just within the urethra, but when inflamed they protrude and appear outside the meatus. When the discharge is not

visible it may be made to exude by pressure along the vaginal surface of the urethra. In doubtful cases the gonorrhœal form is to be suspected when the inflammation is severe, the secretion profuse and purulent, when the disease shows a marked tendency to invade neighboring folds or extensions of the mucous membrane, and when it is difficult of cure. The symptoms of extension to the bladder are often present. Over-frequent micturition may, however, be due to reflected irritation. In the later or chronic stages redness and secretion, as well as all the other symptoms, are less intense. In the chronic form the *mucosa* may be thickened and infiltrated without pain or tenderness. The prognosis is much more favorable than in the male. The symptoms are less severe and the cure more rapid, on account of the shorter urethra.

Treatment.—It is, in the main, the same as in the male. In the mildest forms it is scarcely called for. In the acute and severe forms it should consist of rest in bed, avoidance of coitus, a bland diet composed largely of milk diluted with potash water, or mucilaginous and alkaline drinks to dilute the urine. Linseed tea is one of the best. Tepid sitz-baths and linseed-tea vaginal injections are very useful. Emmet strongly advises hot-water vaginal and urethral douching. At a later stage a solution of nitrate of silver of a strength varying from ten to thirty grains to the ounce, cautiously injected or applied by a camel's-hair pencil or applicator with cotton-wool, or a probe coated with solid silver nitrate, will be found very efficacious. These applications are very painful, but a preliminary application of a four to eight per cent. solution of hydrochlorate of cocaine will very much lessen the pain. The application is to be repeated in from three to six days, if necessary. Professor Winckel, of Munich,[4] advises cold vaginal injections and compresses, or the introduction of pieces of ice within the vagina. Urethral injections are not so useful as in the male, on account of the difficulty in retaining the fluid a sufficiently long time. The balsamic remedies, copaiba and cubebs, are useful in the later stages. Quinine and iron are often necessary to complete the cure.

When the glands described by Dr. Skene, in the floor of the urethra, are inflamed, it may be necessary to devote special attention to them ere they can be cured. The protrusion of their orifices from the urethra often simulates caruncle, and Dr. Skene himself has made the mistake of confounding the two affections. This fact may account for the reputed tendency of caruncle to recur. The proper treatment is to inject the follicle with a few drops of a solution of silver nitrate or other astringent, or, if this fail, to slit them up and cauterize their whole tract with solid silver nitrate.

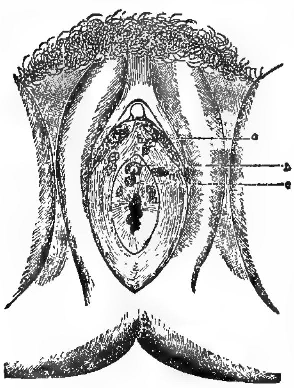


FIG. 411.—Caruncles of Orifice of Urethra. (After Sir J. Y. Simpson.)

NEOPLASMS OF THE URETHRA.—A variety of new growths occurs in the female urethra; and much more frequently than in the male. They have been incorrectly lumped together as "caruncle, spongy excrescence," etc. Winckel has conveniently grouped them according to their minute structure, and the particular histological element of the *mucosa*, from which they spring. Hence there are growths in which the papillary element predominates—condylomata; growths in which the glands are enlarged or diseased—retention cysts, myxo-adenomata, and mucous polypi; growths in which the connective tissue is concerned—fibroma and sarcoma; growths composed of altered blood-vessels—angioma and varix; growths in which both papillæ and blood-vessels are involved—vascular tumors and polypi; growths in which the epithelial element predominates—epithelioma and carcinoma. Condylomata are warty-like, red or dull-red, insensitive, pedunculate, not bleeding easily, and usually projecting from the urethra singly or in clusters. Retention-cysts do not always project, but they may be pedunculate. The fibromata are very rare, but may attain the size of a goose-egg. Sarcoma is rare; Fig. 412 represents a case from Beigel. Varices are dilated veins, and produce bluish-red, painless, compressible swellings. The most important of all the neoplasms of the female urethra are the vascular growths or polypi, called by Winckel papillary polypous angioma. They are of the size of from that of a hemp-seed up to that of a hazel-nut, bright red and bleeding easily by touch, often exceedingly sensitive, and composed of blood-vessels and papillæ, and may affect any portion of the urethra. Lupous and cancerous growths are rare, and usually secondary to uterine cancer. It is well to remember, in this connection, that syphilitic ulceration may affect the urethra.

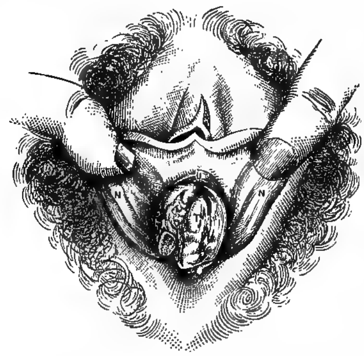


FIG. 412.—Sarcoma Urethræ. (From Beigel.)

Symptoms of Urethral Growths.—They are not rarely absent, or consist only of slight burning sensations. This is especially true of small condylomata, fibromata, retention-cysts, and mucous polypi. If they grow to any size the symptoms become more marked, and consist of itching, pricking, and burning, with vesical disturbance. Micturition is sometimes distressingly painful. In the case of tumors of considerable size, the urethra becomes dilated, inflamed, eroded and fissured, or ulcerated. The pain may radiate to the hips, sacrum, thighs, and feet. It is increased by exertion, walking, standing, and at the menstrual periods. Sometimes there is such general hyperæsthesia of the vulva as to prevent sitting or coitus. It is a cause of vaginismus and sterility. Masturbation and abnormal sexual excitement sometimes result. Rarer consequences are convulsions and serious disturbance of general health from pain, loss of rest, and chronic discharge of catarrhal and bloody fluids. If there be retention of urine the bladder and kidneys suffer. The stream of urine, when not completely obstructed, is often thin, parted, and mixed with blood.

Diagnosis.—Careful examination usually at once decides the question. Pain and tenesmus of the bladder, and painful sitting, are symptoms which demand imperatively an examination. When the growths are in the deeper part of the urethra compression of the urethra forward may bring a pediculated growth to the orifice. A urethral speculum, and a bright light, as from a laryngoscope mirror, may reveal the growth. Dilatation of the urethra may be necessary. This should be done under ether, or after the application of cocaine, which for such purposes finds most valuable applications. During the process of dilatation the growth may not be easily distinguished. Emmet's button-hole operation is a much better procedure for both the diagnosis and removal of the tumor. A most careful and thorough examination of such cases ought to be made, as otherwise the radiating pains may be attributed to uterine disease.

Causation.—Urethral neoplasms are found at all ages, even at birth. They are most frequent in married women. Chronic inflammatory and congestive conditions of the urethra strongly predispose to their formation.

Course and Prognosis.—The majority may be extirpated with more or less of ease and certainty, and do not tend to recur. Such are condylomata, fibromata, mucous polypi, and cysts. Polypi are sometimes detached spontaneously

and escape with the stream of urine. The angiomata, on the other hand, on account of the pain and intense irritation they cause, and the strong tendency to recur, are more unfavorable. These latter are happily exceptional, for they embitter the life of the sufferer. Lupus, epithelioma, and carcinoma are, as a rule, incurable.

Treatment.—The absence of symptoms or complaint, and of any element of danger in many urethral growths, renders interference unnecessary. For those situated near the orifice of the urethra, the treatment is removal with blunt-edged scissors, and cauterization of the raw surface with a point of dull, red-hot iron or nitric acid. The growth itself only is to be removed. To remove any of the mucosa of the urethra may lead to stricture. For those situated in the upper part of the canal preliminary dilatation or button-hole incision of the urethra will be necessary. Then the scissors or a short Simon's or Volkmann's spoon, of small size, will be necessary. Hæmorrhage may always be arrested by the dull, red-hot iron point, or by pressure with the finger. For epithelioma and other malignant growths, free excision must be practised. If the neck of the bladder is not interfered with, there need be no fear of incontinence of urine. When extirpation is not possible, the patient, on general prinples, must be made as comfortable as possible.

Foreign Bodies in the Urethra.—These have been found to be of the greatest possible variety. They may come from the interior of the patient's own body, or be introduced from without. To the first class belong intestinal contents, gall-stones, contents of dermoid tumors, such as hair, teeth, bone; parts of extra-uterine fœtations, hair and bones; vesical and renal calculi; parts of the bladder-walls, as when the mucosa becomes exfoliated. In the second class may be mentioned hair-pins and other pins, bits of pencil, bits of wood, ears of grain, bits of catheter, etc. The symptoms are pain and difficulty in making water, or, for a time, complete obstruction of the urethra. Careful examination by inspection and vaginal palpation and by the sound leads to a diagnosis. For the extraction of such foreign bodies, the urethra may require dilatation or excision from the vaginal surface. After removal of the offending body, the opening may be closed with silk or metallic sutures, and will readily unite.

Neuralgia of the urethra has been described. There can be no doubt that if such symptoms as pain and spasm of the urethra exist, independently of local lesion or irritation, they may be properly spoken of as of neuralgic origin. Such cases, however, are exceedingly rare, and must be regarded with suspicion; they should be admitted to exist only after careful and repeated examination has excluded all other causes. The treatment most likely to give relief is diluent and demulcent drinks, to render the urine bland and unirritating, warm sitz-baths and vaginal douches, and anodyne, rectal, or vaginal suppositories. The use of metallic sounds of full size, passed through the urethra, is likely to do much good.

Displacements of the Bladder.—The organ may be displaced in any direction, and it may be inverted completely through the urethra. The pressure or traction of ovarian and uterine tumors, or of the gravid uterus, may cause upward displacement. Retroflexion and retroversion of the uterus, especially when gravid, produce upward and backward traction on the posterior wall of the bladder. The lateral displacements may be a result of adhesions or hernia, inguinal or femoral. Such displacements are attended with symptoms directly in proportion to the extent to which the urethra is compressed or stretched, and thereby evacuation of urine, by natural effort or by catheter, interfered with. The urethra and bladder are thus apt to become inflamed. These displacements usually disappear on removal of the cause.

Vaginal Cystocele.—This is the most important and most frequent form of displacement of the bladder. It always constitutes a portion of the structures displaced, and, indeed, is usually the first to descend, in procidentia uteri. Cystocele is descent of the base of the bladder, and, with it, of the anterior vaginal wall.

Causes.—These are mainly the conditions incident to pregnancy and labor. The bladder is in these conditions loosened in its attachments, hyperæmic, and irritated by pressure. During the second stage of labor it is apt to be displaced by the advancing head. Relaxation of the vulva and vagina, and laceration of the perineum conduce to cystocele. If the parts be thus predisposed, exertion, as in lifting, straining at stool, etc., may suddenly or gradually induce it. Calculus of the bladder, sinking to the lower part by its weight or by becoming sacculated, may cause cystocele. In the mildest degree there is merely descent of the floor of the bladder. In a more marked form the organ is of hour-glass form, the connection of the urethra with the viscus being at the hour-glass contraction. In complete cystocele the whole bladder is outside the pelvis, and the urethra then corresponds to the neck of a bottle in the upright position. In time cystocele is complicated by thickening and softening of the structures of the bladder from stasis and œdema, and direct hypertrophy of the muscular coat. The mucosa is hyperæmic and catarrhal. The ureters may become obstructed and dilated, with resulting hydronephrosis and uræmic symptoms.

The *symptoms* are a part of those of prolapse of the uterus and vagina. There is difficulty and discomfort in making water; this is sometimes impossible till the prolapsed part has been replaced. Such symptoms may be absent; they are more certain if the urine be catarrhal and ammoniacal. In rare cases cystocele of the distended bladder has impeded labor, and cases are reported in which, it being impossible to pass the catheter and so remove the obstruction, it has been punctured by a lancet, the labor then terminating rapidly. Ultimately, in many cases, adhesions form in the pelvic peritoneum about the bladder (pericystitis), which may render it impossible to replace the prolapsed organ.

Diagnosis is easy. In the standing position a pouch or smooth, elastic swelling of the anterior vaginal wall descends. In the lying position it may be absent, but an effort of forcing will readily cause it to protrude. When protrusion of the organ has taken place, a curved sound passed through the urethra can be made to enter the protruded pouch.

Prognosis must be guarded.

Vaginal cystocele may usually be palliated by the use of pessaries, tampons, and other treatment, but this is often irksome to the patient. The only radical treatment is by operation. Marion Sims, Emmet, Simon, Hegar, and others, have devised operations, very ingenious, often successful, but not always permanent in their results. The indications in treatment are replacement and retention. The former is easy, the latter often difficult. In the majority of cases there is some descent of the uterus as well as of the bladder, and this must be treated at the same time. Any relaxed or inflamed condition of the vagina is to be first removed as far as possible. This is to be done by applications of solutions of iodine or silver nitrate—of the former Churchill's solution (75 grs. iodine and 90 grs. of potassium iodide in one fluid ounce of rectified spirit), of the latter thirty to forty grains to the ounce of water are to be selected. This is to be followed by a glycerine tampon; in the intervals hot-water vaginal douching or linseed-tea injections are to be used; subsequently astringent vaginal injections of decoction of oak-bark or of solution of alum should be employed. Tampons of cotton-wool, wool-wadding, or oakum saturated with a solution of alum and boracic acid, or of carbolic acid in glycerine (℞. Pulv. aluminis, ℥ ss.; acid. boracic., ʒ j.; glycerinæ, ℥ x., after a formula of Dr. Bell, of Glasgow), are very useful and even curative in their tendency. The patient herself may be taught to insert these tampons, and they may be worn two or three days without becoming offensive. A variety of pessaries have been used, and occasionally with advantage. The Hodge pattern certainly sometimes answers well. Greenhalgh's modification, which consists in the attachment of elastic transverse bars, is valuable. The transverse bars help to retain the prolapsed pouch. Skene highly commends a pessary devised by himself (Fig. 413). (For further

consideration of this subject, including the various operations for narrowing the vagina and otherwise curing prolapsus uteri, see article Displacements of the Uterus and Vaginal Walls.) A very rare form of displacement of the bladder is inversion through the urethra. Of this affection Winckel has found only three cases on record. In all of them it presented the appearance of a vivid red, round swelling, projecting from the lower part of the pelvis. Before replacement is attempted, if there be much inflammation and swelling, it may be necessary to reduce this by warm baths, soothing fomentations with narcotics, opiate enemas, etc. Replacement is to be effected by finger-pressure or by a well-oiled, large-sized catheter. The knee-elbow position will much favor replacement. Anæsthesia may be necessary. To retain the organ a catheter, if it can be borne, may be kept in the bladder. Pressure on the urethra from the vagina, by means of tampons, or a colpeurynter, or other vaginal pessary, may succeed better. Adhesive plaster has been successfully adapted with the same object in view. Attempts have been made to effect a radical cure by cauterization of the vesico-urethral orifice and neck of the bladder, and by astringent injections.

FIG. 413.—Skene's Cystocele Pessary.

RUPTURE OF THE BLADDER.—This formidable accident rarely occurs in any but the distended condition of the organ, and is the result of violence. The greater the distention the less the force necessary to cause rupture. A fall on the abdomen, a blow or a kick on the hypogastrium, have been the common causes. The distention of the organ from retroflexion or retroversion of the gravid uterus, and that so frequently following labor, are instances of the special predispositions of the sex. The commonest and most dangerous site of rupture is at the fundus and posterior wall of the bladder, where it is covered with peritoneum. But the anterior wall may also be ruptured. In the first instance, the urine flows into the peritoneal cavity with almost certainly fatal results. In the second, it flows into the cellular tissue, and may infiltrate this to a great extent, even to the navel. The symptoms come on promptly and consist of a sensation of something having given way, violent pelvic and abdominal pain, vesical tenesmus, inability to pass urine, tympanites, nausea, vomiting, cold sweat with urinous odor, collapse, and speedy death. The prognosis is very bad. Of 97 cases collected by Winckel only 6 recovered. Fifty per cent. died in 5 days; thirty per cent. in 5 to 10 days, the remainder in 10 to 20 days. The most favorable cases are those of anterior rupture, in which there is urinary infiltration of the cellular tissue, but no involvement of the peritoneum. Suppuration usually results, but if the urine and products of inflammation be promptly evacuated by free incisions the woman may get well.

Treatment.—When the history and symptoms are clear, the catheter is to be passed. If fluctuation be detected in the hypogastrium, incisions must be freely made to allow the escape of urine and products of consequent inflammation; then the urethra is to be rapidly dilated to admit the finger, and, the rent having been found, a catheter is to be passed through it to evacuate the fluids there present; then a suitable drainage-tube, with wings, is to be introduced through the rent and retained. If the progress of the case be favorable this is to be exchanged, later, for a smaller one.

Abdominal section and drainage is a mode of treatment which may be indicated, and is certainly, in suitable cases, quite justifiable, in view of its great success in analogous conditions. If, in the subsequent course of the case, there be evidences of encysted fluid felt through the posterior vaginal cul-de-sac, it must be evacuated and the cavity drained. Hypodermatic injections of ether or brandy are indicated for the collapse, while opium must be given to allay pain and arrest the movements of the abdominal and pelvic viscera.

TUMORS OF THE BLADDER-WALLS.—The neoplasms of the bladder are mucous polypi, polypoid hypertrophy and cysts of the mucosa, papilloma, fibroid tumors, fibromyoma, sarcoma, carcinoma, and tubercle. They do not differ from the same growths in the male. The symptoms are similar—frequent and painful passing of water, which may be in a fine stream or drop by drop; hæmorrhage is a common and most important symptom; sensations of weight, pressure, or actual pain in the loins, sacral region, thighs, or along the urethra, are common. These symptoms are commonly worse at the menstrual periods. The urine may be bloody, purulent, offensive, and ammoniacal; fragments of the growth may be passed by the urine, and under the microscope may afford valuable indications. Secondary disease of the bladder-coats, ureters, and kidneys is common. Death may occur from anæmia, hæmorrhage, uræmia, or peritonitis, but the duration of the case may be many years—nineteen years in one case on record. In the case of the benign growths, appetite and digestion often remain fair, in spite of the great sufferings of the patient.

The *diagnosis*, except by dilatation of the urethra or vaginal cystotomy and introduction of the finger, is not easy. Persistent hæmaturia, with or without the other symptoms, would justify these modes of exploration. The first step to the removal of the growth, when practicable, would thus also have been taken. Removal of portions of the growth with the curette, and examination with the microscope, may afford valuable information.

Prognosis.—In the benign tumors this is fairly good. Certain of them may be safely removed, and usually without any fear of recurrence. Such are polypi and papilloma. Tuberculosis may last from one to two years. The malignant growths seldom last more than a year.

Treatment.—In the case of polypi and papilloma removal is the only proper treatment. The urethra is to be dilated or the bladder opened by incision of its base through the anterior vaginal wall. A pair of forceps, the finger-nail, a snare, ligature, or the curette, as the case may indicate, is then to be used. The operation by incision of the bladder has the great merit over dilatation of the urethra that it attains the object in all cases. This cannot be said of dilatation of the urethra. The occurrence of the not very rare permanent incontinence of urine after the latter operation renders it a procedure which, though easy of performance, is to be regarded with suspicion. After cystotomy, moreover, hæmorrhage from removal of the growth and the attendant cystitis may be more easily dealt with. The incision may be a mere longitudinal incision, or it may be T-shaped, as the necessities of the case may require. It may be closed immediately or left open, for a time, so that the cystitis so often present may be allowed to get well or may receive proper treatment. For this purpose, Dr. T. A. Emmet speaks highly of the value of injections of large quantities of hot water into the bladder through the incision. All these procedures must be conducted with the greatest gentleness. For the control of hæmaturia, rest in bed, ice in the vagina, bladders of ice-water to the hypogastrium, vesical injections of solutions of silver nitrate, half a grain to the ounce of water, or one fluidrachm of tincture of perchloride of iron to four fluidounces of water, may be employed. As internal astringents, tincture of perchloride of iron, turpentine, dilute sulphuric acid, fluid extract of ergot, and gallic acid are all useful. They must be given in full doses, when necessary. The addition of opium will often be indicated. Belladonna is often a most useful sedative. Either of these drugs is often best given by suppository in the rectum. In case of retention of urine the catheter must be used, but always with the greatest gentleness. Myomata and fibromata are very rare, and unless pedunculate are difficult of removal. The malignant growths are susceptible of palliation only. Narcotics must be used in sufficient doses to control the pain and vesical tenesmus. The artificial vesico-vaginal fistula

may, however, be feasible as the most efficient means for the relief of the latter symptom, as the coats of the bladder are thereby completely set at rest.

INFLAMMATION OF THE BLADDER (CYSTITIS).—*Morbid Anatomy.*—In the first stage, or mildest form, hyperæmia of the mucosa is noticed. This frequently leads to bleeding. Persistence of hyperæmia leads to increased secretion—catarrh. If the urine now become septic (it is especially apt to become so if mucus be present), the croupous form of cystitis may result. In still more severe forms—such as may result from foul catheters, and from diphtheritic inflammation with extension to the muscular and serous coats—parenchymatous cystitis and pericystitis may be found. In the worst forms, abscess and gangrene or sloughing of the bladder-walls may obtain. In bad cases all the anatomical lesions here enumerated may be present, illustrating the successive steps, from the mild beginning to the advanced stages of the most severe form. In the stage of congestion the mucosa is bright red from gorging of minute blood-vessels. These easily give way and bleeding in varying amount ensues. The bleeding may occur into the substance of the tissues—ecchymosis. Blood poured into the bladder may escape with the urine, or coagulate and form a clot which becomes gradually broken up and partly decolorized, and is expelled as shreds. Varicosity of the veins may exist in chronic congestion or during pregnancy. The tendency to hæmorrhage thus produced is very obvious.

Vesical catarrh may be acute or chronic. In the acute form at first the vessels of the mucosa are gorged, but the epithelium is entire. In parts, however, it soon becomes separated. As the acute stage subsides the redness ceases to be general, it becomes patchy, and a slimy mucus covers the membrane. Patches of slaty discoloration appear. These are due to changes in blood previously extravasated. By a continuance of the process, the disease becoming chronic, swelling with polypoid hyperplasia of the membrane results. The process extends to the other structures — connective tissue, muscular coat, and even peritoneal investment. In the presence of muco-purulent secretion, decomposition of the urine with generation of carbonate of ammonia readily ensues. This renders the urine alkaline, and, as a consequence, precipitation of earthy phosphates takes place and this precipitate is deposited on the ridgy prominences of the folds of the swollen mucosa. Ulceration is an early consequence of this condition, but the muscular coat resists it for a time; in severe cases, however, it is undermined, and strands or bridges of muscular fibre appear in the bladder. The peritoneal coat is thickened and hyperæmic, and presents, on its surface, band-like adhesions extending to adjacent viscera and parts. Septicæmia from absorption through ulcers is not rare. Perforation and infiltration of urine may ensue from extension of the ulcerative process. In the worst forms of inflammation gangrene ensues. The muscle is paralyzed. The bladder is distended with a chocolate-colored fluid, consisting of urine with an admixture of pus, altered blood, and urinary sediment. The croupous and diphtheritic forms merit a word or two of special comment. They may be partial or general. In the croupous form a layer of exudation of fibrine with leucocytes invests the surface of the mucosa, in part or in whole, forming a cast of the organ. In true diphtheritis vesicæ the exudation extends into the substance of the mucosa, and, it may be, even to the muscular and serous coats. In either form the partial or complete separation of the vesical mucosa may result, and in certain cases on record a complete cast of the bladder has been expelled with great pain and distress. Fig. 414 represents a remarkable case described by Schatz. It was one of cystitis with gangrene and separation of a sac consisting of the mucous membrane, connective tissue, and part of the muscular coat, from the rest of the bladder-wall; it occurred with retroflexion of the gravid uterus.

FIG. 414.

Symptoms.—These, though usually pronounced enough, are sometimes, according to Emmet, quite insidious in their onset. In simple vesical catarrh the patient complains of sensations of pressure, pain of varying intensity, and frequent straining attempts to pass water. Fever is absent. The urine is turbid, brown from blood, opaque from mucus and pus, or dense and whitish from triple or amorphous phosphates. In mild, favorable cases the symptoms subside in from ten to fourteen days, and the membrane becomes normal. If the disease advances and ulcerative changes take place, the pain and tenesmus become more violent. The pain is explained by the spasmodic squeezing together of the tender coats of the bladder as it becomes empty. Such pain may not only be pelvic or perineal, it frequently radiates to the sacrum, umbilicus, or breast. The changes in the urine are important. At first of normal reaction and specific gravity, it is apt to become of low specific gravity and alkaline reaction. The alkali is partly that of mucus, but is mainly ammonia from decomposition of urea. This is a result of the retention of urine, and also of the introduction of bacteria, as by foul catheters and in other ways. In chronic cases the odor is not only intensely ammoniacal, but also exceedingly fetid from decomposition of organic material. The sediment in acute cases is light and flocculent, consisting of muco-pus and triple and amorphous phosphates. In chronic cases it is heavy, brown or dirty yellow, and consists of pus, blood, epithelium, shreds of tissue, and crystals. If the alkalinity be excessive, the mucus is very ropy or stringy, adhering to the sides or bottom of the vessel. When the kidneys are involved, in addition to the other microscopic elements, there are renal tube-casts. These may be either small, light granular, hyaline, epithelial, bloody, or darkly granular in character. In the course of cystitis some disturbance of adjacent parts may occur. The uterus, as a matter of course, from its position most frequently suffers. Subinvolution, congestion, and leucorrhœa are not rare. Pelvic peritonitis and cellulitis are also complications, or rather the result of extension of the inflammation or of perforation or gangrene of the whole bladder-wall. Well-marked symptoms indicate these complications. In chronic cases systemic poisoning, from renal disease pre-existing or set up secondarily, or from absorption of putrid urine through ulcerated or abraded patches in the bladder, is a common occurrence. Uræmia is indicated by a soporific condition, headache, vomiting, and diarrhœa. Septicæmia is indicated by chills, high temperature, and sweating in the best marked cases. In cases of diphtheritic cystitis there may be retention of urine, and the introduction of a catheter may fail to draw off any urine. This is due to obstruction of the holes of the instrument by the false membrane.

Diagnosis.—In every case presenting the symptoms just described the practitioner ought to make a careful examination of the pelvic organs. This examination ought to be digital, bimanual, and by the vaginal speculum. The urethra must be explored for tumors and inflammation. It may be necessary to pass the catheter and to use a bladder-sound. The urine must be carefully examined for albumen, epithelium, casts, pus- and blood-cells, crystals, flakes of epithelium, or shreds of membrane. The conditions with which cystitis is most apt to be confounded are: urethritis and other diseases of the urethra; fissure of the neck of the bladder; displacements of the uterus, as prolapsus, especially when complicated with cystocele; retroversion and anteversion; perimetritis and parametritis, in which case there is probably epi- or peri-cystitis; pregnancy, and certain neuroses. In all these affections or conditions micturition may be frequent and painful. The urine is not, however, specially changed, nor is vesical tenesmus a symp-

tom, unless, as is quite possible, cystitis actually coexists. Fissure of the bladder-neck is to be recognized by dilatation of the urethra, and exploration with finger and endoscope, or probably better still, by Emmet's method of button-hole incision of the urethra, and subsequent exploration of the neck of the bladder. In vesical neurosis the urine is healthy, and the disturbance of micturition very variable in degree, or even at times entirely absent. In diseases of the urethra tenesmus, as a rule, is absent. The pain and burning are felt during the act of micturition, which is not over frequent, as the bladder may be tolerant of a large quantity of urine. The presence of pus in the urine is not of itself to be regarded as certain evidence of cystitis. It may come from a neighboring abscess which has perforated the bladder, or from the kidney, etc. A tumor in the loin and intermittent flow of pus in large quantity are symptoms of pyelitis. In urgent cases, when the diagnosis remains doubtful after the less radical methods of examination have been tried, the urethra must be dilated, and the bladder explored by the finger or endoscope. In this way tumors and calculi may be certainly excluded or discovered, and the first step will have been taken for their removal or for other therapeutic measures. The possibility of permanent incontinence of urine following this operation leads certain eminent authorities to prefer vaginal cystotomy, by which an opening is established through which the bladder may always be thoroughly explored. The fistula thus produced is much more certainly remediable by operation than is the injury which may be inflicted by dilatation of the urethra. It has, further, the great merit of being curative in its results, as well as useful for diagnostic purposes.

Etiology of Cystitis.—The causes are various. It is certainly true that cold is a common cause. Chilling of the general surface, but especially of the hypogastrium and feet, exerts a powerful influence in this direction. Over-distention by itself, or associated with cold, as during a long cold drive, is another common cause. From motives of delicacy, from neglect, or from a lack of suitable accommodations, women often suffer seriously from over-distention of the bladder. Rheumatic and gouty conditions of the system certainly predispose to vesical inflammation. The commonest causes are, however, probably those incident to pregnancy and parturition. Retroversion of the gravid uterus favoring the retention of urine and over-distention of the bladder is a common cause of cystitis. This need not excite wonder if we reflect upon the conditions present. During the later stages of pregnancy, and especially during labor, the mucosa is hyperæmic and congested, and it may be abraded through pressure by the presenting part and also through over-distention. After labor the bladder is again frequently over-distended from retention of the urine. Inattention on the part of the midwife or accoucheur may easily permit such a distention of the bladder to become excessive—a condition which of itself may cause cystitis. But if to this be superadded the ungentle or unskilful use of the catheter, the danger is greatly increased, for abrasions of the mucosa of the swollen and often displaced urethra and bladder are thus easily produced. Cystitis is not rarely produced by the frequent use of the catheter, as after perineum operations and laparotomy. Winckel believes the mucous membrane of the bladder to be the part of the body most sensitive to septic poison. If this be true, and there is no reason to doubt it, the danger of foul catheters is obvious. Experiments on animals have shown that septic or alkaline urine does not cause much irritation if the vesical mucosa be sound; but if it be abraded, then severe cystitis results. The disease may also be excited by an inflammation of the adjacent vagina, uterus, peritoneum, or cellular tissue. Gonorrhœa frequently thus extends to the bladder through the urethra. Cancer of the uterus and vagina often invade the bladder. Abscesses occasionally burst into it and produce inflammation. This is also true of extra-uterine gestation sacs, dermoid cysts of the ovary, and suppurating ovarian cysts. The eruptive fevers, typhus, small-pox, scarlet fever, and measles are sometimes complicated with cystitis, especially the croupous form. Injuries, other than those mentioned as incident to labor, such as blows or falls over the bladder, especially if it be distended, may prove to be the starting-point. In this connection Dr. Skene draws attention to the importance of regular emptying of the bladder, especially when travelling. Excess in sexual intercourse, or violence in the act, may also operate as a cause. Certain drugs which are excreted by the urine may irritate and inflame the bladder. Such are alcohol, asparagus, onions, cantharides, turpentine, arsenic, and other substances.

Prognosis.—It is favorable in the mild forms, in which only simple hyperæmia, with bleeding or catarrh, exists. Suitable regimen and treatment lead to cure in from ten to fourteen days. Quite different is the prospect in the croupous, diphtheritic, and gangrenous forms. In these the prognosis is always grave. The earlier the nature of the case is understood and suitable remedies are employed, the better the chances of cure. Long persistence of the ammoniacal condition of the urine is very injurious. Perseverance in suitable local treatment will, however, even in these severe cases, frequently result in cure. Adhesion of the bladder to neighboring viscera complicates the case considerably, as it tends to prevent complete evacuation, and renders necessary the use of the catheter with its attendant dangers of admission of air and septic matters. Severe chronic cystitis, with ulceration or sacculation of the bladder, is a most obstinate and often incurable disease.

Prophylaxis.—Most of what may be said on this point, has been anticipated in the remarks on etiology. It will not, however, be out of place even at the risk of repetition, to warn the practitioner of certain avoidable dangers. The parturient and lying-in woman must be carefully guarded against over-distention of the bladder. No statement made by patient or nurse on this head is to be accepted as reliable. The practitioner must examine for himself. If the catheter be necessary, it must be a clean and new one, if it be flexible. A metallic catheter, while not so suitable under certain circumstances, presents the advantage that it may be easily and thoroughly disinfected, as by boiling water or the flame of a spirit-lamp. A number of small openings near the end are better than one or two large ones. It not rarely happens that in the latter case the mucosa of the bladder is drawn into the openings, and becomes abraded during the forcible withdrawal of the instrument. A source of danger is the introduction, by means of the catheter, of septic matter from the discharges bathing the vagina and vulva. This may be prevented, however, by irrigating these parts with an antiseptic lotion, immediately before the catheter is introduced.

Curative Treatment.—In all but the very mildest cases, the patient must be put to bed, the skin got to act gently, and a mild, unstimulating, and liquid diet prescribed. It is important to render the urine as dilute and unirritating as possible. If it be highly acid, doses of from ten to twenty grains of the bicarbonate, citrate, or acetate of potash in half a tumblerful of water, every four hours, will be useful. The same object is attained by large draughts of super-carbonated potash-water, Apollinaris water, linseed tea, or decoction of triticum repens. Milk and potash-water form an admirable combination. A milk diet alone greatly conduces to the cure of cystitis. It may be taken cold or warm, skimmed or not, as the patient may fancy, but must be taken in large quantities. If there be appetite, and if the temperature be normal, the patient may be allowed eggs and the lean part of fresh meat. Sauces, condiments, spices, and seasoned food generally must be avoided. The bowels must be kept regularly open. On the importance of this point two eminent authorities, Skene and Winckel, agree. For this purpose, salines are the best laxatives. Hunyadi, Vichy, Congress, Apollinaris, or other mineral waters, or a teaspoonful or two of Epsom salts in a large glass of water will answer if taken fasting. Skene reports having seen a case of cystitis, of several months' duration, cured by a severe attack of cholera morbus. Alkalis must not be pushed too far. The indication is merely to render

Bladder.

highly acid urine slightly alkaline. Decided alkalinity is to be avoided, as this condition leads to precipitation of phosphates, and possible formation of calculi. Certain vegetable diuretics are useful. Buchu is one of the best; the infusion is the best preparation. It is a good vehicle for the alkalis, or other necessary drugs.

Benzoic acid, or the benzoate of ammonia, is a useful medicine in cystitis. It forms a good combination with infusion of buchu. Pain and tenesmus must be controlled by narcotics and sedatives. It is better to avoid opium as long as possible, and to give only what may be necessary to control urgent symptoms.

Hyoscyamus, belladonna, hops, or camphor may suffice. The bromides and hydrobromic acid are often most valuable, but must be given in full doses. When opium or morphia are needed the rectal suppository is to be selected as the best method of administration. When the acute stage is passed, balsamic drugs are useful. Those to be preferred are copaiba, balsam of Peru, tar, turpentine, oil of sandalwood; compound tincture of benzoin is also a good selection. The association of much pus and mucus in the urine, with slight pain, calls for the astringents. The uva ursi, in full doses of the decoction, is one of the best. Mustard and linseed-meal poultices to the hypogastrium, and copious hot-water vaginal douching are most useful. Such measures may, and often do, suffice for the mild cases, but in the severer forms they often fail. In cases of every grade of severity, when the symptoms do not yield in a few days, vesical injections must be used, lest the use of the most efficacious of all the remedies be unduly delayed. The topical use of remedies in affections of the bladder is a most valuable resource, provided the mode of administration be skilful; otherwise the treatment may be injurious. Gentleness is all-important, lest the urethra or bladder be abraded, or worse injured. Forcible injection or much distention is to be avoided. For these reasons the fountain-syringe is the best.

A cheap and efficient apparatus is the following: A glass funnel holding four ounces, one and a half or two feet of rubber-tubing, and a gum-elastic catheter, No. 7 or 8, English, shortened to eight inches. The rubber-tubing is attached by one end to the funnel and by the other to the catheter; the point of the catheter must merely enter the bladder, lest by violent contact, from forcible contraction, or otherwise, the mucosa be abraded. To provide for this a flange or guard of thin wood or of flat rubber, one-eighth inch thick, and perforated, is slipped over the end of the catheter to a distance of two or three inches from the point. The apparatus described is simple, efficient, and cheap. With the necessary materials at hand, the physician can get such an apparatus ready in a few minutes. It is the safest to entrust to the patient or attendant when this must be done. The patient lies on her back; the catheter is introduced; the fluid is poured into the funnel; it is gently raised above the level of the bladder; the fluid enters. After a few minutes' contact with the interior of the bladder, it is withdrawn by lowering the funnel below the level of the bladder.

Much good is often done by injections which merely wash out the bladder. Plain warm water is very useful. A weak solution of sodium chloride or potassium chlorate is better. A strength of from three to five grains to an ounce of water is suitable. A solution of carbolic acid, one to sixty, will check suppuration and remove fœtor. Certain astringent drugs are often useful. Acetate of lead, sulphate of zinc, alum, and tannic acid, each may be used in the strength of from one to three or four grains to the ounce of water. The most valuable of all is the silver nitrate. This is only in keeping with what we know of its value in inflammations of other mucous membranes. It has often been used in the strength of one to two grains to the ounce, but such solutions are much less efficacious than stronger ones. The writer can vouch for the efficacy and safety of solutions of from twenty to forty grains to the ounce; one ounce of the solution may be allowed to flow into the bladder and after a few minutes permitted to escape. It causes severe pain for a short time only, as a rule. The hypodermic syringe ought to be at hand in case of necessity.

The writer believes that a sufficiently early use of these strong vesical injections might obviate the necessity for the operative procedures for the cure of cystitis, to be presently described. As a rule they ought to be administered to the patient lying in bed. The writer has, however, administered them to a patient in his office, and has sent her home in a cab, without preventing the good results. The inefficiency of the weaker solutions, and the safety and efficacy of the stronger ones, may be explained by partial precipitation of the silver salt by the chlorides of the urine and by the vesical mucus. Mr. Coulson strongly advises and reports cures by injections of nitric acid—one drop of the strong acid to an ounce of water. Dr. Skene has used two drops of nitro-muriatic acid to the ounce. Anodyne injections have been used with benefit. One to two grains of morphia to the ounce of water is a suitable formula; ten to fifteen grains of chloral to an ounce of water is another.

In severe or neglected cases of cystitis all such measures fail, and if the patient is to be cured, *rest*, so conducive to the recovery of every diseased organ, must be secured to the bladder. This has been sought in a variety of ways. Drainage of the bladder by a catheter retained in the urethra has, in some cases, answered admirably, because of the rest thereby secured. But it is only in exceptional cases that at a first attempt the urethra will thus tolerate the presence of a catheter, but in many, after persevering efforts have been made, the canal becomes tolerant. Dr. Goodman succeeded in several cases by employing a catheter, two inches long, bent to correspond to the curvature of the urethra; at the lower or external end there is a button, ten-sixteenths of an inch in diameter, and at the other a shoulder expansion, varying from five-sixteenths to seven-sixteenths of an inch in diameter, perforated with a number of small holes. In favorable cases this catheter is self-retaining in all positions of the patient. In many cases a perfectly flexible rubber catheter will answer as well, or better. Fig. 415, *a*, illustrates Holt's self-retaining catheter, and *b*, a modification of it found very useful by Dr. Skene.

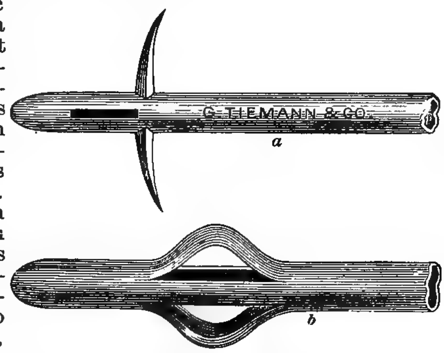


FIG. 415.—*a*, Holt's Self-retaining Catheter; *b*, Skene's Modification.

The modification consists in cutting the catheter into strips near the end; these strips are then made to spread out like an umbrella, the gap or space thus created taking the place of the eye (Fig. 415, *b*). Every such instrument must be regularly removed and thoroughly cleansed. Rapid dilatation of the urethra has, in a number of cases, cured cystitis. It is supposed to act by securing rest and drainage; inasmuch as incontinence commonly follows for a few days. But this incontinence is sometimes permanent and incurable—a most formidable objection to the procedure. None of these measures secures the desired object at all so perfectly as does the next to be mentioned, viz., vaginal cystotomy, or artificial vesico-vaginal fistula. The late Dr. J. Marion Sims, on one occasion, left open for some months the incision in the vesico-vaginal septum through which he had removed a calculus. The objects which he had in view were rest of the organ and facility for local treatment of the consequent cystitis. This suggested to Dr. Emmet the same operation for obstinate cystitis, however induced. To him is due the credit of having popularized a most beneficent procedure, which will lead to the cure of cases otherwise incurable. By the opening thus made, the blad-

der-muscle is set completely at rest. The urine drains away as fast as it trickles from the ureters. The patient is at once relieved from pain and the loss of rest from the incessant attempts to empty the bladder. Through the opening, the bladder is regularly irrigated with plain warm or medicated water. With proper precautions the operation is not difficult or dangerous, and when no longer necessary the opening can be closed in the ordinary way. This must usually, however, be delayed for several months.

I will now describe these two operations, both of which have been frequently alluded to in the foregoing descriptions. Like most of the procedures employed by the gynæcologist they are of value both for diagnostic and for curative purposes.

Rapid Dilatation of the Urethra.—This has been performed in a variety of ways. The outer end of the urethra is the narrowest and least distensible part, and it is very apt to be lacerated. The late Professor Simon, of Heidelberg, devised a set of dilators for performing this operation. He claimed that by these instruments the danger of the greatly dreaded permanent incontinence was reduced to a minimum. Such instruments are, however, unnecessary. The dilatation may be begun with a uterine two-bladed dilator. When this has commenced the process, a series of small rectal bougies may be made to follow, till first the little finger, and finally the index finger, have been gently coaxed through the urethra into the bladder. The advantage of a finger in the bladder, for purposes of diagnosis, are obvious. It is not alone in diseases of the urethra and bladder, but also in many conditions of the uterus that much information may be thus gained. From a therapeutic point of view it will suffice to mention that calculi, growths, and foreign bodies have frequently been thus removed with perfect success. For this purpose it is quite practicable to pass by the side of the finger a forceps, lithotrite, or other instrument of similar form that may be required. The great objection to the operation is the very considerable danger of permanent incontinence resulting from laceration of the urethra at its upper part. If the whole number of such cases could be collected it would certainly be considerable. That care, skill, and experience cannot always prevent it is shown by the fact that the accident has occurred to the most eminent surgeons. The result is a most distressing infirmity. Union of the lacerated surfaces may be secured, but this will not restore retentive power to the bladder.

Vaginal Cystotomy.—With proper precautions this operation is neither difficult nor dangerous of performance. A sound is introduced within the bladder and its point made to project on the anterior vaginal wall in the middle line and a little behind the neck of the bladder. The projecting tissues are steadied by a tenaculum and by scissors, and the opening into the bladder is made and extended to about an inch in length. The point just indicated is selected to avoid the ureters and certain important blood-vessels at the neck of the bladder. The main difficulty in the after-treatment is to keep the incision open. To obviate this Dr. Montrose Pallen makes the incision by the knife of the thermo-cautery. Dr. Bozeman removes an elliptical portion of the base of the bladder. Dr. Emmet formerly inserted a glass eyelet into the opening. Dr. Bache-Emmet devised a fistula tube (Fig. 416), with the double object of maintaining the opening and conducting away the urine to a receptacle. The object is probably attained with the greatest certainty by Dr. Emmet's most recent modification of the operation, which consists in uniting, by fine carbolized silk sutures, the edges of the vaginal and vesical mucous membrane in the incision. Dr. Emmet points out an important source of danger in the use of ether for the performance of this operation. The cases of cystitis which call for this operation are not rarely complicated with extension of the disease to the ureters and kidneys. If the urine contain tube-casts ether is to be avoided as dangerous, and opium in a full dose is to be used instead. The operation, if it is to cure the patient, must be done before the kidneys have become involved. It is usually necessary to keep open the fistula for several months—long enough to render the cure certain. The operation for its closure is performed in the ordinary way.

FIG. 416.—Bache-Emmet's Fistula-tube.

VESICO-URETHRAL FISSURE.—Such a condition is believed by certain authorities to be far from rare. It is a crack or fissure between the folds of the mucosa, at the point of junction of the urethra and bladder. It presents the appearance of an elongated, grayish-red, ulcerated spot, with the greater part of its length in the urethra. The great suffering attendant on this condition is due to irritation by the urine, which excites painful spasmodic contractions.

Symptoms.—They are not reliable. They resemble those produced by cystitis and urethritis. The patient complains of a constant feeling of desire to micturate, with burning pain referred to the neck of the bladder. There is much straining, and after micturition the pain and burning are most intense. The diagnosis is often difficult. Cystitis and urethritis are the conditions with which it may be confounded, but with which it is also often associated, and which are not rarely its cause. The absence of the products of cystitis in the urine would exclude that disease. Dr. Skene claims to have often diagnosed it by his endoscope. Emmet has never succeeded in thus recognizing its presence. For the majority of observers it will be diagnosed by excluding cystitis and urethritis in the presence of the subjective symptoms just described. The causes are urethritis and cystitis, which get well everywhere except at one point. The causes of cystitis and urethritis are, therefore, remotely those of fissure. Hence injuries during labor, from the catheter, and those produced during the passage of small calculi, may establish the lesion.

Treatment.—In view of the great suffering which attends the disease, this is most important. Emmet believes in the efficacy of only one remedy, namely, rest to the muscular coat, by opening the urethra in the manner already described, if the symptoms are not very urgent, or if more pronounced, the bladder, and treating the case as for cystitis, which condition, if it does not exist, must inevitably be produced. When the bladder has been opened, the edges of the wound are to be held apart by a double tenaculum. A laryngeal mirror with flexible copper shank is then held in the bladder, and, by a tenaculum, the folds in the mucosa at the neck are separated, when, if a fissure exists it will be seen. The subsequent treatment will be the same as for cystitis, viz., injections of hot water, and, in addition, a slight incision of the fissure with a scalpel, as is practised in cases of fissure of the rectum.

Vesical and urethral injections and instillations are of little or no value. Cauterizations as well as an incision through the urethra, are difficult to practise. Dilatation of the urethra is easy enough of performance, and is sometimes efficacious. It need not be carried to any great extent, such as may entail the risk of laceration or permanent incontinence. Professor Skene's method is to ascertain that size of sound which can be passed with ease, and then to pass in succession three or four larger sizes. This is often sufficient. The urine ought to be rendered as healthy as possible before the operation, and so maintained afterward.

FOREIGN BODIES AND CALCULI OF THE FEMALE BLADDER.—There are three possible sources:

1. From neighboring parts and viscera from which the foreign bodies find their way into the bladder by perforating ulceration. Such are the contents of ovarian cysts, of dermoid cysts, of extra-uterine fœtation sacs, of loops of the intestine, and of the gall-bladder. From the latter sources portions of ingested food, worms, etc., and biliary calculi may reach the urinary bladder. Echinococci may find their way into the bladder from neighboring structures in the pelvis. From the kidney, by way of the ureter, renal calculi and portions of the structure of the kidney may come to the bladder.

2. Foreign bodies introduced from without. The greatest possible variety of objects have been found in the bladder, having been introduced into it by masturbating, insane, and prurient women. The induction of abortion appears to have been the object in certain cases. Hair-pins and other pins, needles, bodkins, tooth-picks, pencils, goose-quills, and pieces of wood are among the objects which have thus reached the bladder. A foreign body in the bladder, if retained long enough, usually becomes the nucleus around which the salts of the urine collect to form a calculus. Fig. 417 represents a large stone formed around a hair-pin; it was removed by vaginal lithotomy by Dr. Angus McDonald, of Edinburgh.

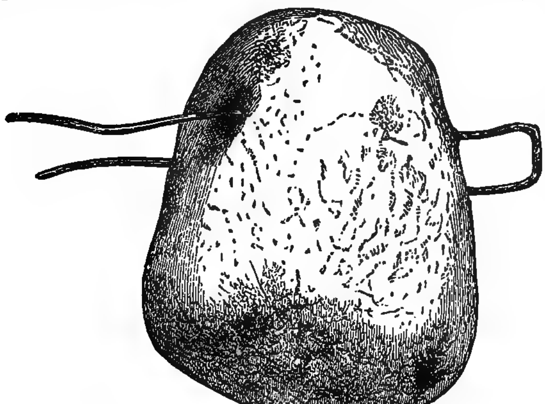


Fig. 417.—Vesical Calculus formed around a Hair-pin.

By accident, a piece of catheter may break off in the bladder during self-catheterization.

3. Foreign bodies which have formed in the bladder. These consist of the various forms of urinary calculi, the composition of which is the same as in the case of those found in the male. Vesical calculus formed from renal calculus as a nucleus, or originating from concretions formed in the bladder, is much rarer than in the male. The dilatability and shortness of the urethra usually permit of their expulsion before they attain a size which prevents this. A large proportion of vesical calculi in women have for a nucleus some foreign body introduced from without. The composition may be uric acid, phosphates, oxalate of lime, or cystine. They occur at all ages, but, according to Winckel, most frequently in children. Every variety of size of calculus, from a grain of sand to a child's head, may be found. The situation is usually the deepest part of the organ behind the trigonum. The stone may be encysted or may lie in a pouch. If it be of large size or if there be several calculi, a prolapse or cystocele of the bladder may result.

Symptoms.—These depend on the cause, form, and other physical characters, the size and number of the stones or other foreign bodies, and upon complications. When the source is from without the bladder, the substance reaching it by perforation, there is a history of pelvic peritonitis with bladder irritation which may be of considerable duration. On the other hand, certain small, round, and smooth substances may exist in the bladder without producing any marked symptoms. In the case of rough, heavy, and rapidly forming stones, the symptoms are severe, and consist of frequent and painful straining attempts to pass urine, which contains pus and blood. Not rarely vesico-vaginal fistula has resulted from ulceration of the floor of the bladder. The pain is not confined to the hypogastrium, but radiates in various directions, both upward and downward. These paroxysms of pain occasionally exist during pregnancy, and may complicate labor in a most important way.

Diagnosis.—The sound is to be passed, and one or two fingers should be introduced into the vagina, when the stone or other body may usually be detected. In the case of an encysted stone or of substances which do not resound to the touch of a metallic instrument, this method may fail. The urethra must then be dilated and the finger inserted, or the vesico-vaginal septum must be incised; and so, while the diagnosis is by this means rendered certain, the operation for removal of the offending body is performed.

Treatment.—This consists in following a single indication—the necessity of accomplishing a prompt removal. This may be done mainly in two ways—through the urethra after dilatation, and by way of an incision made through the vesico-vaginal septum. The first method is to be resorted to only in the case of small friable stones or other substances, and in the absence of severe inflammation of the bladder. The amount of dilatation required to permit of the introduction of forceps and of the extraction of the foreign body is so considerable that the danger of the terrible and irremediable result, of permanent incontinence of urine, is very great. In the case of soft stones of moderate size the lithotrite may be used, and the fragments washed out. In all cases in which the foreign body is of moderate or large size, and especially when the cystitis is severe, the method by incision is to be preferred; the opening being left open for treatment of the cystitis. The mode of performance of these operations, and the subsequent treatment of the bladder, have been already described. When a vesical calculus is found in a woman in labor it ought to be promptly removed, as otherwise the danger of serious injury to the bladder during the delivery of the child is very great.

William Gardner.

[1] Skene: Diseases of the Bladder and Urethra in Women. Wm. Wood & Co., 1878.
[2] Emmet: Principles and Practice of Gynecology, 3d edition, 1884.
[3] American Jour. Obst., vol. xiii., page 265.
[4] Billroth's Handbuch der Frauenkrankheiten, 9. Abschnitt.

BLADON SPRINGS. *Location and Post-Office*, Bladon Springs, Choctaw County, Ala., on the Tom Bigbee River, eighty-five miles north of Mobile, whence it is accessible by boat.

These springs were opened to the public in 1844, and have long been the favorite resort of the inhabitants of the Gulf States. Situated in the pine forest, and remaining open all the year round, they offer unusual inducements to invalids from the Northern States. The climate is equable, the air dry, and the mean temperature of the year about 50° F.

During the fall and winter the shooting is excellent, the game being deer, fox, and wild duck. A pack of hounds is kept near by. There are four springs.

Analysis.

One pint contains—	Vichy Spring. 67° F. (J. L. and W. P. Riddell.)	Branch Spring. 67° F. (J. L. and W. P. Riddell.)	Old Spring. (Prof. R. T. Brumby.)	Sulphur Spring. 67° F. (J. L. and W. P. Riddell.)
	Grains.	Grains.	Grains.	Grains.
Carb. soda	5.791	5.151	4.111	4.367
Carb. magnesia	0.036	0.076	0.170	0.081
Carb. iron	0.062	0.029	.....	0.095
Carb. lime	0.109	0.267	0.344	0.302
Chloride sodium	.....	.....	0.962	.....
Sulphate lime	0.282	0.349	0.002	0.370
Sulphate iron	.....	.....	0.030	.....
Sulphate manganese	trace	.....	.....	trace
Silica and alumina	.....	.....	0.263	.....
Crenic acid	.....	.....	0.091	.....
Hypocrenic acid	.....	.....	0.075	.....
Organic matter	0.282	0.237	.....	0.156
Loss	.....	.....	0.040	.....
Total	6.562	6.112	6.088	5 371
Gases.	Cubic in.	Cubic in.	Cubic in.	Cubic in.
Carbonic acid	8.18	7.40	4.07	6.61
Sulphuretted hydrogen	trace	trace	undet'd	0.07
Chlorine	0.23	0.23	....	0.23

Therapeutic Properties. These are alkaline waters slightly charged with carbonic acid gas. They are useful in catarrhal diseases of the lungs, alimentary canal, and urinary organs. They are diuretic, and render the urine alkaline. By their use the appetite increases and the general health improves.

There is one large hotel. *Geo. B. Fowler.*

BLASTODERM. Blastoderm is a term of somewhat varied signification according to the animal to which it is applied, and, indeed, according to the stage of development. The blastoderm of vertebrates is different from the so-called blastoderm of many invertebrates. The term is applied especially to meroblastic ova, but is also used in reference to the mammalian ovum; it designates the layer or layers of cells, which partially or completely cover the yolk, and directly participate in the formation of the embryo. *The blastoderm may be defined as the stratum of cells resulting from segmentation of the ovum, and not belonging to the yolk.* We cannot enter into a detailed comparison of the blastoderm throughout the animal kingdom; let it suffice to point out that the structures so-called are by no means always homologous. Thus, in insects, segmentation is partial and produces a single layer of cells (Fig. 418), which gradually spreads over the yolk and apparently represents only the ectoderm. In vertebrates, however, the blastoderm is more complex, and consists, in most forms, of several layers of cells, or rather at first of a thick stratum of cells not separated into distinct layers until later stages. The typical vertebrate blastoderm can, perhaps, be best seen in the eggs of bony fishes. The disposition has been very carefully studied by Dr. C. O. Whitman, to whom I am indebted for the accompanying semi-diagrammatic figure (419) of the ovum and blastoderm of a flounder. The ovum is surrounded by a vitelline membrane, *z*, from which it has slightly withdrawn, notably at the upper pole, where lies the thick cap of cells constituting the blastoderm, *Bl;* in the stage represented the outer layer of cells is just becoming marked off as a distinct layer, the ectoderm; underneath the blastoderm is the well-marked segmentation cavity, *s.c.;* everywhere at the edge of the blastoderm lies the segmenting zone, *kw.*, a ring of granular protoplasm with rapidly dividing nuclei; the cells resulting from these divisions are added to the edge of the blastoderm, which thus enlarges by peripheral additions as well as by the proliferation of its component cells. The segmenting zone is prolonged inward, forming the floor of the segmentation cavity, or as it is named, the subgerminal plate, *s.g.* This plate grows in from the preriphery toward the centre; it contains nuclei and thins out from the edge of the blastoderm inward. The segmenting zone, *kw.*, is essentially the homologue of the germinal wall of the amniota, which has been described under Area, but it is sharply bounded against the yolk, and in that respect differs from the wall in the chick, because in the latter the germinal wall merges gradually into the yolk.

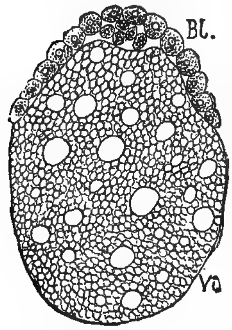


Fig. 418.—Section of Egg of Oniscus Murarius. (After Bobretzky.)

In the ovum of elasmobranchs (sharks, etc.), we find, at the so-called close of segmentation, that the blastoderm is a lenticular mass of cells, a little thickened at one point where the primitive streak arises later, and resting at its edge upon the very large yolk, which forms an encircling zone of segmentation around the blastoderm; between the mass of cells and the yolk there is a cavity commonly described as the segmentation cavity. If this designation be correct, then the comparison with the teleost ovum is direct and evident. It is possible, however, that the space under the blastoderm is not the true segmentation cavity, but the entodermic cavity, as maintained by Balfour; in other words, that the disposition of parts is the same as in the birds, which we proceed to describe.

The birds and reptiles being very closely related, we find very close resemblances between the blastoderms in the two classes. The actual homologies of the parts have been worked out as yet only in the birds, but there cannot be much doubt that essentially the same features exist in the blastoderm of reptiles. Duval has recently

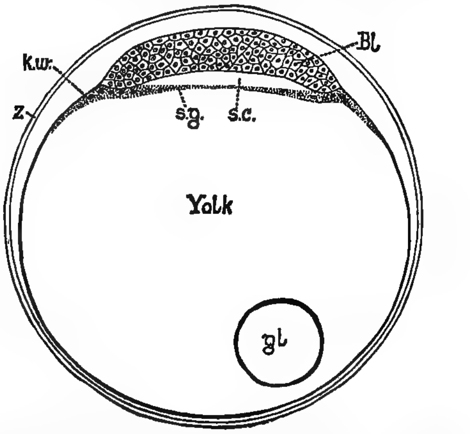


Fig. 419.—Ovum of a Flounder in Transverse Vertical Section Semi-diagrammatic. *z*, Vitelline membrane; *kw.*, segmenting zone (Keimwall); *Bl*, blastoderm; *s.c.*, segmentation cavity; *s.g.*, subgerminal plate; *gl*, oil-globule of yolk.

shown that in birds the primitive blastoderm represents only the ectoderm, as is the case also with the amphibia; it is separated from the underlying yolk by a distinct cavity; in birds this cavity is very small, and is overlaid by a single row of cells, the ectodermal or primitive blastoderm; the cavity is very soon obliterated by the development of cells below it, and these cells, together with the outer layer first formed, constitute the secondary blastoderm, which, therefore, contains first the young ectoderm, and second, a deeper-lying stratum of cells,

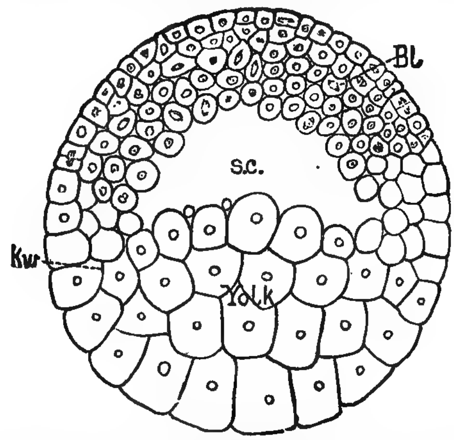


Fig. 420.—Egg of Axolotl after Segmentation. Transverse section. *Bl*, primitive or ectodermal blastoderm; *s.c.*, segmentation cavity; *kw*, (Keimwall) germinal wall; *Yolk*, segmented yolk. (After Bellonei.)

shown by their subsequent history to be the mesoderm united with part of the entoderm; in other words, at this stage the mesoderm and entoderm are not distinct. Underneath this compound blastoderm appears a second cavity, which is not what it has been often called—the true segmentation cavity—but is entodermic, being bounded by the true entoderm above and the yolk below; the yolk, it must be remembered, is modified entoderm. In birds (and probably reptiles) the thick blastoderm of the teleost is represented only by a few cells; the secondary

blastoderm is another structure, consisting of two layers, and developed later.

The similarity between the eggs of ganoids and of amphibians permits us to consider these two classes together. At first sight the segmented ovum of an amphibian seems very unlike that of the mesoblastic vertebrates, but if we begin by the study of parts obviously identical, I believe that we can determine the homologies of all the parts. Fig. 420 represents a transverse section of an ovum of an axolotl; the membranes of the ovum are not represented. The parts can be readily compared with those in the teleost; the blastoderm, *Bl*, is very large in proportion to the whole ovum, and is composed of several layers of cells, all of which belong to the ectoderm, and at this stage are found to be multiplying with extreme rapidity; the yolk is segmented, and accordingly consists of large cells; at the edge of the yolk, *kw*, is the zone where cells are being added to the blastoderm. and which is, therefore, the homologue of the germinal wall; the segmentation cavity is very large, *s.c.;* the yolk-cells bounding it inferiorly may, perhaps, be homologous with the nucleated subgerminal plate of teleosts. The segmentation cavity is ultimately obliterated, and a secondary blastoderm, including the three germ layers, is developed, as described in the article Fœtus, Development of. Underneath the secondary blastoderm arises a second distinct, or true entodermic cavity (Fig. 425). The relations are strictly comparable, therefore, to those in the birds.

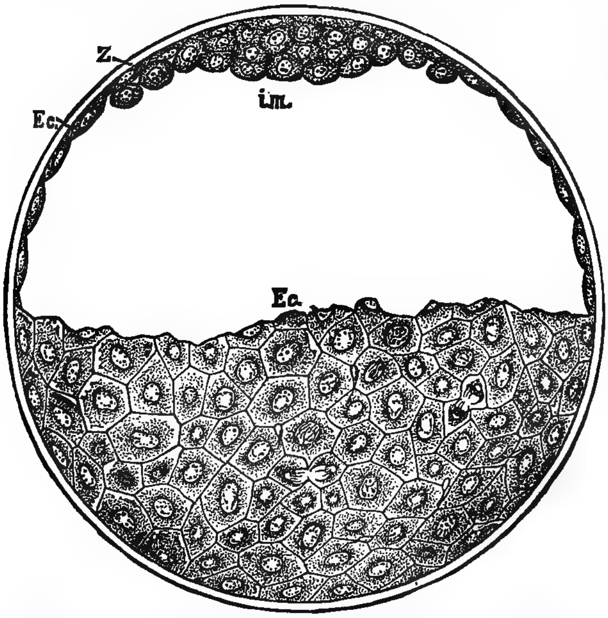


Fig. 421.—Ovum of Rabbit; ninety-four hours after coitus. *Ec*, external cell layer; *i.m.*, inner mass of cells; *Z*, zona pellucida. (The upper half represents an optical section, the lower half a surface view.) (After Van Beneden.)

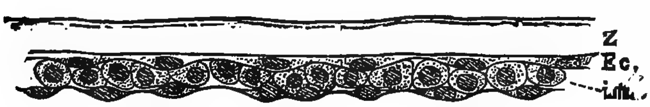


Fig. 422.—Section of Rabbit's Blastoderm, of five days and four hours. *Z*, zona pellucida; *Ec*, ectoderm; *i.m*, inner mass. (After Van Beneden.)

The mammalia, according to the descriptions hitherto given, offer no homology in the blastoderm stage with other vertebrates. The formation of the blastoderm is described under "Segmentation." The result of segmentation is the so-called blastodermic vesicle, a hollow sack formed by a single layer of cells (Fig. 421, *Ec.*) lying close against the zona pellucida; at one pole, where the embryo is subsequently formed, lies a lenticular mass of cells, *i.m.* Now, the exact relations of this cell-mass have never been thoroughly studied by anyone with a view of elucidating the homologies of the parts, all investigators having apparently come to a tacit agreement to neglect this problem. Van Beneden, to be sure, attempted an interpretation by calling the outer vesicle the ectoderm, and the inner mass the invaginated entoderm, thus defining the whole as a modified gastrula. It has since been definitely settled that Van Beneden was in error in this. Our knowledge of the changes that take place in the inner cell-mass, is based almost wholly upon the study of various rodents (rabbit, guinea-pig, and mice), all which pass, during their early development, through phases which obviously represent great modifications of the normal mammalian ontogeny. In the rabbit the cells where the inner mass lies soon form three layers (Fig. 422); these are not, however, the three germ layers; for, as Rauber has shown, the two outer layers form the ectoderm, and the third inner layer forms the entoderm; the mesoderm arises later. Here, then, we reach a definite point of comparison; the whole of this mass of cells performs the role of the secondary blastoderm in the chick, teleost, and frog; I therefore conclude that it is the mammalian blastoderm. The second point to be made is that the so-called cavity of the blastodermic vesicle is probably the segmentation cavity enormously enlarged. Hence comes the third point, that the cellular vesicle represents not the ectoderm, as has hitherto been universally assumed, but the yolk-sack hollowed out. We must, therefore, find a second, or true, entodermic cavity distinct from this; but the origin of the entodermic cavity is currently stated to be a transformation of the cavity of the vesicle; so that there is no distinction between the segmentation and the entodermic cavities, a conclusion which is simply incredible. The solution of the puzzle must come from future investigations.

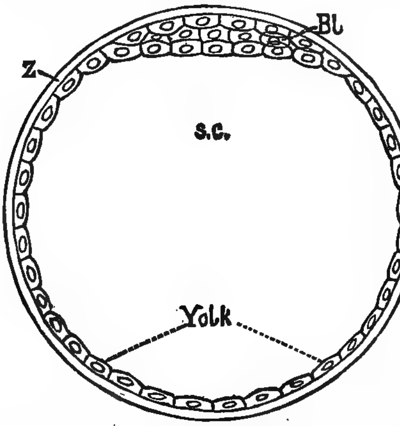


Fig. 423.—Diagram of a Segmented Mammalian Ovum. *Bl*, blastoderm; *s.c.*, segmentation cavity; *Yolk*, layer of cells, representing the remnant of segmented yolk.

For convenience of comparison with Figs. 419 and 420, the accompanying diagram of a mammalian ovum after segmentation is given. According to the identification of homologies I have here hypothetically advanced, the blastoderm, *Bl*, must be entirely ectodermic, and the true entoderm must arise later in connection with an invagination. As the occurrence of such a process is at present a pure assumption, the venturesome nature of the hypothesis need not be further emphasized.

It appears to me that the invagination of the ectoderm, to which I hold the inner cell-mass to correspond, is a general phenomenon in the development of placental mammals, and that the remarkable inversion of the germ-layers in the guinea-pig is only a persistence of this early invagination. It is a law which, as I pointed out several years ago, holds throughout the animal kingdom, that the result of segmentation is to produce two sets of cells, one of small-sized cells, belonging to the ectoderm, the

other of larger cells, belonging to the entoderm. In mammals also segmentation produces the two kinds of cells, but the smaller ones (ectoderm) form the inner cell-mass. Van Beneden committed the mistake of calling it entoderm. It seems to me clear that this first invagination is ectodermal, and so has nothing to do with a gastrula invagination. The inner cell-mass gradually flattens out again in most cases, but in some mammals it remains permanently turned in (guinea-pig, arvicola, etc.). The process of the flattening-out of the inner cell-mass is shown in Fig. 424, which represents sections. In the mole the inner mass is nearly globular, *A*, and quite small in proportion to the whole vesicle. It soon becomes lens-shaped, *B*, and next separated into three layers, *C*, the outermost of which disappears; the middle layer becomes the ectoderm of the embryo; the innermost, part of the entoderm. These changes are discussed in the article Fœtus. For the present it must be said that we have no clear notions as to the passage of the segmented mammalian ovum into the embryo, because we do not know yet either the history of the segmentation cavity nor the origin of the entodermic cavity.

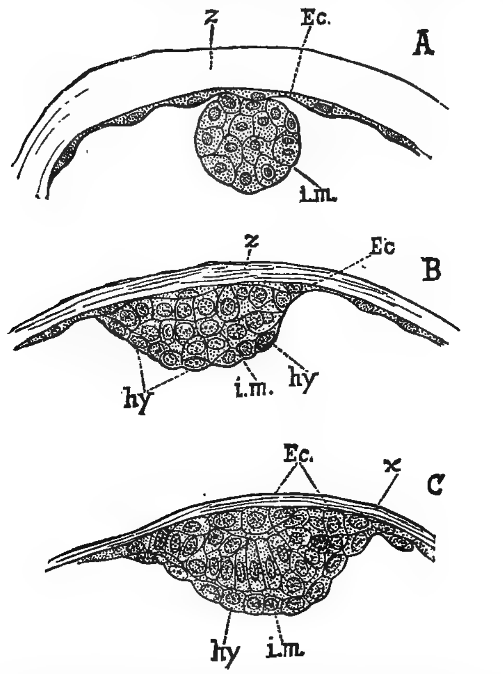


Fig. 424.—Sections through Three Successive Stages, Ovum of the Mole, to show the changes in the inner mass, *i.m.* *z* and *x* designate the zona pellucida; *Ec.*, subzonal cell layer, usually called ectoderm, but probably entoderm; *hy*, portion of the inner mass, which enters into the composition of the entoderm of later stages. (After Heape.)

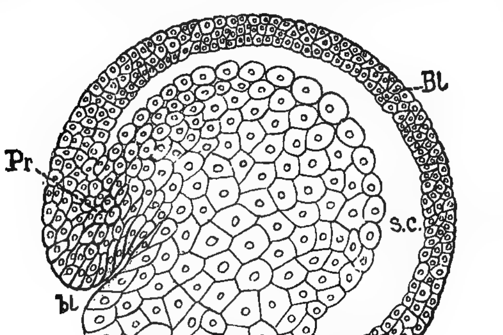


Fig. 425.—Egg of Axolotl, Longitudinal Section. (After Bellonci.) *Bl*, primitive blastoderm; *Pr*, accumulation of cells, showing the commencement of the secondary blastoderm; this accumulation corresponds to the primitive streak of birds; *bl*, blastopore and commencement of the entodermic cavity.

Conclusions.—The blastoderm of (probably all) vertebrates passes through two stages: the *primary blastoderm* consists of ectoderm only, which is separated, except at its edges, from the yolk by the segmentation cavity; the *secondary blastoderm* is constituted by portions of the three primary germ-layers, which overlie a second cavity belonging to the entoderm and lying behind and separated from the segmentation cavity; the secondary blastoderm is the commencement of the embryo.

The history of the changes in the secondary blastoderm is given under Fœtus. We will note here only the nature of the first step, which is an accumulation of cells, appearing at the posterior end of the blastoderm, and which is known in the higher vertebrates by the name of *the primitive streak.* It is almost the first step toward the addition of inner layers to the ectoderm or primary blastoderm, and it remains recognizable for a considerable period at the hind region of the blastoderm or germinal area.

(The substance of this article and the illustrations are borrowed from an unpublished embryological work.)

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Charles Sedgwick Minot.

BLASTOPORE. In the lower vertebrates, notably in the Ganoids, Cyclostomata, and Amphibia, there appears during the formation of the entodermic cavity a small opening at the posterior edge of the blastoderm. This opening leads directly into the entodermic cavity, and is known as the blastopore. It persists during early embryonic life. This opening is best seen in a longitudinal section (Fig. 426). The blastoporic opening leads into a descending canal, which directly communicates with the posterior, or caudal, end of the entodermic space, which lies between the yolk, *Vi*, and the dorsal entoderm, *Ent.* The appearances of the ova of the lamprey, or of any amphibian, at a corresponding stage, are closely similar to those of Fig. 426.

The blastopore is also found in reptiles, birds, and

mammals, but the recognition of its occurrence in these forms was long hindered by the fact that it does not exist

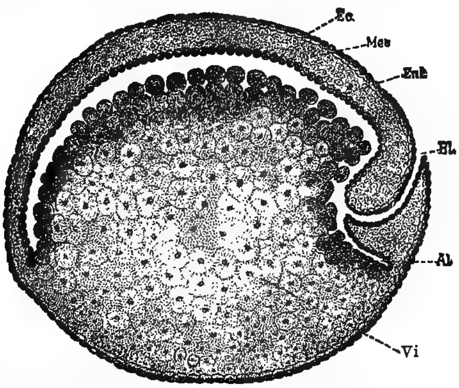

Fig. 426.—Longitudinal Section of an Ovum of the Sturgeon after the Formation of the Entodermic Cavity. *Ec*, ectoderm; *Mes*, mesoderm; *Ent*, entoderm; *Bl*, blastopore; *Al*, diverticulum of the digestive tract; *Vi*, yolk. (After Salensky.)

at first as a canal. The blastopore is the external opening of a tube passing through the primitive streak, or the thick mass of cells at the posterior end of the blastoderm (or later embryo). Now, if from any cause the walls of the tube grew together, the lumen would disappear, and the primitive streak would become a solid mass of cells. This is the condition we actually find in the amniota, Fig. 427, A. Now, since the primitive streak really is morphologically the thick walls of the blastopore, the homologies are not altered by the temporary disappearance of the canal, especially as the canal reappears as such in later stages, at first as a pit upon the external surface, Fig. 427, B, *bl*; this pit soon becomes a complete perforation, Fig. 427, C, *bl*.

It is a remarkable but very common phenomenon in vertebrate development to encounter tubular organs existing temporarily as solid cell-masses in the embryo. This occurs with most glands, the Wolffian duct, the vagina of man, the urethra in the penis, the nares, the meatus auditorius externus, the posterior part of the medullary canal in the axolotl, the intestines of teleosts, etc. There is, therefore, nothing specially remarkable in the temporary absence of the blastoporic lumen, and the want of an opening is not a valid argument against the homology of the amniote blastopore with that of the amphibia and similar forms.

The true blastopore is distinct from the anus of Rusconi of the amphibia (see under Germ Layers). (For the relation of blastopore to the nervous system, see Neurenteric Canal.)

The blastopore usually disappears by closure, and a new posterior opening, the true or permanent anus is formed. Miss Johnson states that in the Triton the anus is the persistent blastopore, an observation of great theoretical importance.

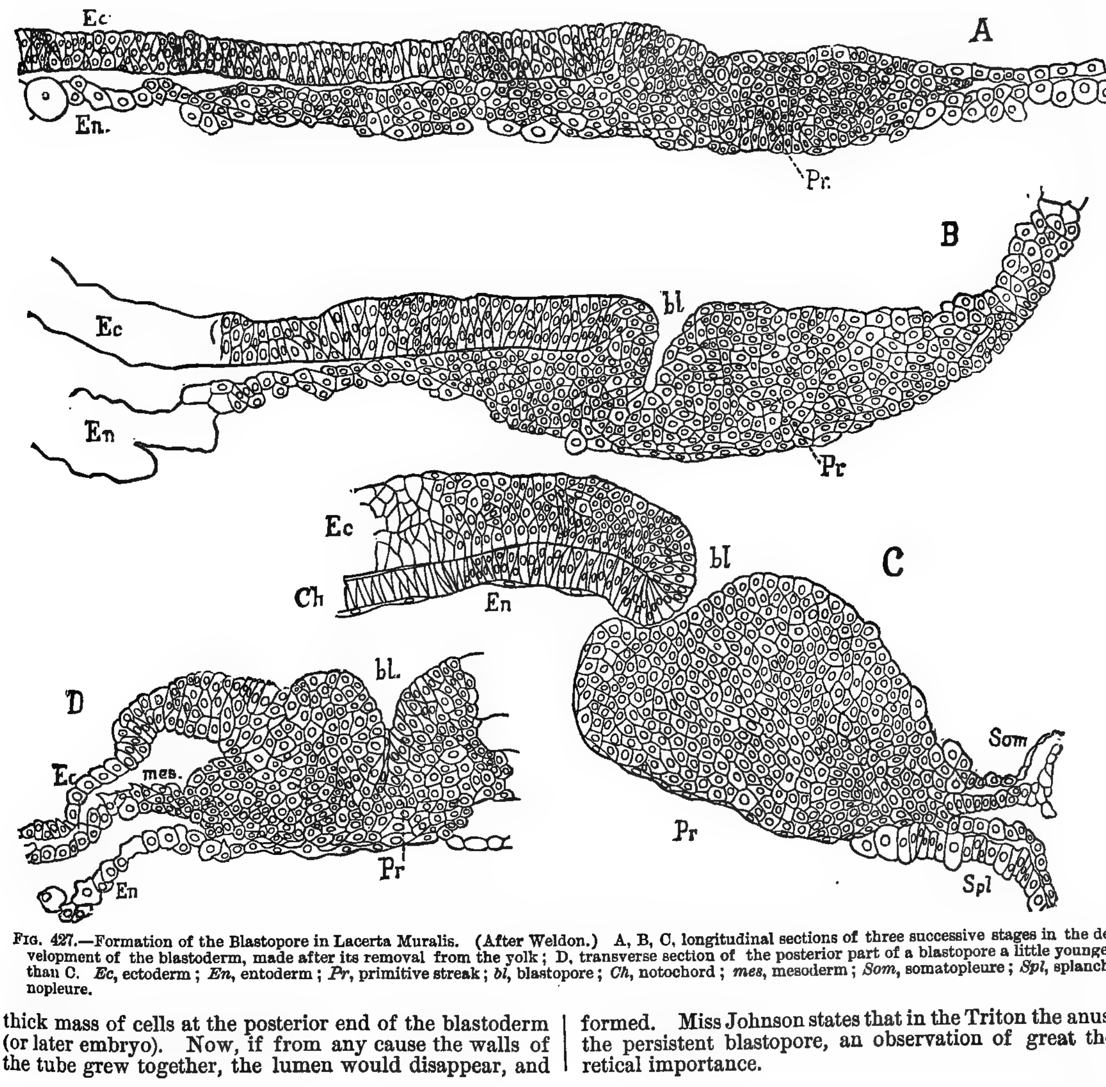

Fig. 427.—Formation of the Blastopore in Lacerta Muralis. (After Weldon.) A, B, C, longitudinal sections of three successive stages in the development of the blastoderm, made after its removal from the yolk; D, transverse section of the posterior part of a blastopore a little younger than C. *Ec*, ectoderm; *En*, entoderm; *Pr*, primitive streak; *bl*, blastopore; *Ch*, notochord; *mes*, mesoderm; *Som*, somatopleure; *Spl*, splanchnopleure.

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The literature of the blastopore is very extensive. The following list cites only a few of the most important articles; those by Balfour and Bellonci may be signalized as of especial value.

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Charles Sedgwick Minot.

BLINDNESS (Lat., *Cæcitas;* Ger., *Blindheit;* Fr., *Aveuglement*). *Amaurosis* is sometimes used synonymously with blindness, and in selected cases—whose cause is obscure, and is located in the nervous apparatus—this is admissible, with the same limitations that apply to blindness. Blindness is a misleading term, being a symptom only, and should not be used in scientific language (except in a generic sense) without a qualifying phrase which describes the condition upon which it depends—as blindness from optic nerve atrophy. A strict application of the term would include only such eyes as are not possessed of light perception. It is, however, usually understood to embrace all eyes incapable of recognizing the outline or shape of objects; and practically it should include all eyes with vision less than $\frac{1}{200}$, *i.e.*, ability to count fingers at one foot, for such individuals have to be *led* around.

The GEOGRAPHICAL DISTRIBUTION of blindness is shown in Table I., compiled by Mayr, of Munich, in 1877.

TABLE I.

Country.	Population.	Total No. of blind.	No. of blind in 10,000.
England and Ireland	31,631,212	31,159	9.85
Denmark	1,864,496	1,465	7.86
Norway	1,701,756	2,320	13.63
Sweden	4,168,525	3,359	8.06
Finland	1,732,621	3,891	22.46
Austria	20,394,980	11,329	5.55
Hungary	15,417,327	18,523	12.01
Switzerland	2,669,147	2,032	7.61
Netherlands	3,575,080	1,593	4.46
Belgium	4,529,560	3,675	8.11
France	36,102,921	30,214	8.37
Spain	15,658,531	17,379	11.26
Italy	26,413,132	26,826	10.16
United States of America	38,558,371	20,320	5.27
Argentine Republic	1,743,199	3,529	20.24
British Colonies in—			
North America	583,535	361	6.19
West Indies	905,730	2,030	22.41
Africa	330,460	416	12.53
Australia	305,730	116	3.79
Germany	39,862,133	35,048	8.79
Total	248,148,446	215,585	8.74

The population of the United States in the above table is taken from the census of 1870. The census for 1880 shows a population of 50,155,783; number of blind, 48,928; number of blind in ten thousand, 9.73. A striking difference is the great increase of blindness in the United States in the last decade, as is shown in the figures for 1880. Various causes must be considered in determining the reasons for this increase in blindness, the most important of which are the following: 1. The census returns were more complete for the last census than they have been heretofore. 2. Injuries more or less remote from the eye, sustained during the late war, continue to swell the ranks of the blind, and with pensions in view a considerable number make the claim unjustly. 3. The foreign element in our population adds to the percentage of blind; for natives of the United States furnish 9.13 blind to 10,000 inhabitants, while 13.45 blind are found in the same number of our foreign population. 4. The increase of manufacturing interest and its spread to localities remote from competent professional care; and 5, the increase of those competitive trades that bring bodily and mental strain, which are liable to produce changes in the nervous system, in which the eyes participate.

THE CLIMATIC INFLUENCE, as illustrated in Europe, is shown in Table II., from Magnus, of Breslau, 1883.

TABLE II.

Between latitudes	30°	and	40°	the number of blind	in 10,000	is	11.09
" "	40°	"	50°	"	"	"	8.63
" "	50°	"	60°	"	"	"	7.55
" "	60°	"	70°	"	"	"	18.04

And for the Western Continent the same author gives Table III.

TABLE III.

Between latitudes	10°	and	20°	the number of blind	in 10,000	is	22.41
" "	20°	"	30°	(vacant).			
" "	30°	"	40°	the number of blind	in 10,000	is	8.96
" "	40°	"	50°	"	"	"	5.36

The hot southern latitudes are injurious, because of their dry, sandy interiors, and the consequent glare, sand, and wind, and their moist, swampy, miasmatic borders and water-courses. The cold northern latitudes are injurious, because confinement in badly ventilated quarters is a necessary concomitant; and, the days being short during the long winters, the work of the eyes is crowded into a limited time, or is prolonged in insufficiently lighted rooms, where work becomes injurious. The most temperate zone presents the least number of these objections, hence we find here the smallest percentage of blindness. There are also geological causes which influence the percentage of blindness—for instance, it is more frequent on one side of the Jura Mountains than on the other. Blindness is more frequent in cities than in rural districts, and this, too, aside from such causes as lead to blindness from injuries and trades.

That there are RACE PECULIARITIES is shown by the fact that out of 10,000 Christians, there are only 9.4 blind, while the same number of Jews furnishes 13.3 blind.

One reason for this large percentage of blindness in Jews, is the great frequency with which they suffer from glaucoma. It is said that the sclera is more dense and less elastic in people of this race than in others, and that this condition favors the development of glaucoma. It has been further claimed that dark eyes are more prone to amaurotic affections than light ones, and that Jews, who usually have dark eyes, are therefore more liable to suffer from blindness. This, however, is not borne out by facts, for dark races are usually possessed of deeply pigmented eyes, yet the percentage of blindness is not great with them. It should be remembered, however, that the so-called amaurotic affections constitute but a small proportion of the causes of blindness; and the fact should not be overlooked that overcrowding and bad ventilation are often found in the class to which the majority of Jews belong—and such surroundings are prolific sources of external inflammations of the eye. Consanguinity in marriages is another cause which renders the Jewish race more prone to blindness than others. They, too, almost invariably live in cities, where the percentage of blindness is higher than in rural districts.

INFLUENCE OF SEX.—The United States has a population of 25,518,820 males, and 24,636,963 females, which gives a preponderance of 871,857 in favor of males. The number of blind males is 26,748, and of females 22,180, which gives a preponderance of 4,568 in favor of the male blind. The number of blind in 10,000 males is 10.48, and in the same number of females 9.02. This difference is a slight one, and can be easily accounted for by the accidents arising from exposure of the eyes to the injurious influences of the trades followed by men. An interesting fact bearing upon this point is the comparative diminution in the percentage of blindness in males after they reach an age which recalls them from pursuits that endanger the eyes to surroundings more nearly like those of females.

Table IV., prepared by Magnus from the Prussian census, illustrates this condition most aptly.

TABLE IV.

Age.	No. of blind, 1871.		No. of blind, 1880.	
	Males.	Females.	Males.	Females.
Under 10 years............	664	558	572	488
10 to 20 years..............	1,113	846	992	823
20 to 50 years..............	3,572	3,336	3,565	2,989
Over 50 years...............	5,752	7,100	6,148	6,975

See in this connection Table VIII., for the causes which produce blindness at different ages.

Table V. gives the percentage of blind *of* different ages in column 2, and the percentage of population *at* different ages in column 3 (Katz), while column 4, which has been adapted from Meyr's table, shows the number of blind in 10,000 *at* different ages.

TABLE V.

Age.	Percentage of blind between the ages given.	Percentage of population.	Number of blind in 10,000
1 to 10 years.....	3.7	24.9	1.75
10 to 20 years.....	4.6	19.9	2.36
20 to 30 years.....	9.8	16.4	3.25
30 to 40 years.....	11.1	13.0	3.81
40 to 50 years.....	15.2	11.1	6.84
50 to 60 years.....	17.3	7.5	11.50
60 to 70 years.....	19.7	4.7	26.23
70 to 80 years.....	13.5	1.8	92.44
80 to 90 years.....	4.3	0.3	207.00
90 to 100 years.....	0.27	0.02	373.20

This table, which is a very interesting and instructive one, deserves attention for its own merits; yet it becomes more instructive when considered in connection with Table VIII., which gives the causes that produce blindness at different ages.

INFLUENCE OF OCCUPATION.—The causes of blindness incidental to occupation, may be divided into two classes, viz.: *Traumatic* and *Non-traumatic.*

Traumatic.—Under this head are included such occupations as necessitate exposure of the eyes to the direct influence of injurious agents from without, which result from the work performed—as machinists, who are constantly exposed to flying bits of metal, which often produce injury of the eye and blindness; and the same is true of blacksmiths, locksmiths, stone-cutters, and miners. The last named are also exposed to the dangers of premature or careless explosions. Cases of *monocular blindness* almost invariably arise from the causes just considered.

Cohn found 535 men with 554 blind eyes, and 241 women with 446 blind eyes. Preference is shown for neither eye. The greater frequency of binocular blindness in females is another argument in favor of the accidental occurrence of blindness from the injurious trades followed by men.

Non-traumatic.—Under this head are included such occupations as produce blindness indirectly—as myopia, from over-use of the eyes. Professional men, whose duties necessitate much study; and others, who, from necessity or preference, do much reading, or much fine work, which requires close and long-continued use of the eyes, are liable to suffer from myopia, and the train of symptoms which in this disease lead to blindness. Workers in lead are liable to suffer from neuro-retinitis, or atrophy of the optic nerves; and workers in india-rubber are exposed to the same dangers, from sulphide of carbon. It is claimed that optic nerve atrophy sometimes occurs in workers who are exposed to the fumes of tobacco, or of alcohol. Soldiers in crowded barracks are apt to suffer from conjunctival diseases, and the exposure to wind, dust, glare, and inclemencies of weather, when marching, may also cause the same trouble. Sailors who are constantly exposed to the vicissitudes of weather are liable to suffer from conjunctival and other forms of eye-disease, and their crowded quarters and often meagre fare are also conducive to eye-affections.

CAUSE OF BLINDNESS.—Table VI. gives an *anatomical* grouping of the causes of blindness, compiled by Magnus from 770 cases.

TABLE VI.

	Per cent.
Conjunctiva..	16.364
Cornea..	10.650
Uveal tract...	22.208
Retina..	16.259
Optic nerve...	22.597
Glaucoma..	12.597
Congenital deformities of the eye.........................	2.468
Unclassifiable	2.857

Table VII., compiled by the same author from a study of 2,528 cases reported by various writers, gives the causes of blindness, arranged in *pathological* groups, and the percentage of each individual cause.

TABLE VII.

A.—*Congenital blindness.*—	Per cent.
Anophthalmus and microphthalmus........................	1.068
Megalophthalmus..	0.435
Congenital cataract......................................	0.119
Choroiditis, congenital..................................	0.158
Atrophy of optic nerve, cong.............................	0.751
Retinitis pigmentosa cong................................	0.751
Congenital blindness with retinal atrophy................	0.079
" tumors..	0.039
" amaurosis, not specified......................	0.237
B.—*Acquired blindness.*—(*a*) From idiopathic diseases of the eye.	
Ophthalmia neonatorum....................................	10.876
Trachoma and blenorrhœa of adults........................	9.492
Diphtheritic conjunctivitis..............................	0.356
Diseases of the cornea...................................	8.068
Irido-choroiditis, cyclitis, iritis......................	8.860
Choroiditis myopica......................................	0.949
Choroiditis, choroido-retinitis..........................	1.107
Retinitis pigmentosa, acquired...........................	1.266
Retinitis apoplectica....................................	0.119
Neuro-retinitis..	0.791
Detachment of retina.....................................	4.746
Glaucoma...	8.978
Idiopathic optic nerve atrophy...........................	7.751
Tumors of the eye and its surroundings...................	0.356
Unclassifiable...	3.368
C.—*Acquired blindness.*—(*b*) Injuries.	
Direct injury of the eye.................................	4.034
Unsuccessful operations..................................	1.938
Injuries of head...	0.277
Traumatic sympathetic ophthalmia.........................	4.509
D.—*Acquired blindness.*—(*c*) The eye disease being in consequence of disease of the body.	
Diseases of the eye from syphilis........................	0.470
Gonorrhœal conjunctivitis................................	0.910
Scrofulous diseases of the eye...........................	0.039
Irido-choroiditis with meningitis........................	1.424
Atrophy of optic nerve, cerebral	6.961
" " " " spinal............................	2.333
" " " " or neuritis following hæmatemesis...	0.396
" " " " after vomiting, not blood..........	0.079
" from hæmorrhage from piles.........................	0.039
" after facial erysipelas............................	0.079
" with insanity......................................	0.039
" " epilepsy.......................................	0.158
" " dysentery......................................	0.079
Retinitis nephritica.....................................	0.198
Diseases of the eye from typhus..........................	0.949
" " " " measles......................................	0.633
" " " " scarlatina...................................	0.514
" " " " variola......................................	2.216
" " " " exanthemata?.................................	0.235
" " " " heart disease................................	0.039
" " " " childbirth and pregnancy.....................	0.431
Intoxication amaurosis...................................	0.039
Blindness from disease of the orbit......................	0.039

Congenital anomalies constitute nearly four per cent. of the causes of blindness. The majority of instances occur as a result of consanguineous marriages, or where there is an hereditary tendency toward defects of the eye, or as a result of syphilitic manifestations in intra-uterine life. They are usually hopeless—cataract being the only cause in this category amenable to treatment.

The various ages at which other causes of blindness arise are well shown in table VIII., from Magnus, which gives the percentage of causes at the ages when they are developed.

TABLE VIII.

Causes of blindness.	Proportion of blindness in 10,000, and the percentage of its causes at different ages.										
	1 to 5 yrs.	6 to 10 yrs.	11 to 15 yrs.	16 to 20 yrs.	21 to 25 yrs.	26 to 30 yrs.	31 to 40 yrs.	41 to 50 yrs.	51 to 60 yrs.	61 to 70 yrs.	71 to 80 yrs.
Ophthalmia neonatorum	1.99	..	..	..	..	..	..	..	..	..	..
Trachoma	..	0.04	..	..	..	..	..	0.07	0.02	00.5	0.12
Injuries	0.01	0.04	0.02	0.05	0.10	0.21	0.13	0.19	0.05	..	..
Optic nerve atrophy of all forms	0.35	0.26	0.27	0.26	0.30	0.28	0.69	0.61	0.47	0.26	0.12
Uveal tract with choroido-retinitis, retinitis pigmentosa	0.27	0.11	0.14	0.13	0.27	0.28	0.25	0.29	0.32	0.49	0.12
Detachment of retina	0.01	0.04	0.07	0.05	0.20	0.24	0.11	0.14	0.29	0.10	..
Glaucoma	.	..	.	..	..	.	0.07	0.27	0.65	1.50	1.30
Operations	..	..	..	..	..	..	0.01	..	0.05	..	0.25
Corneal diseases	0.27	0.04	0.04	0.02	0.13	0.14	0.05	0.04	0.14	0.10	..
Variola	0.13	0.04	..	0.02	..	..		0.02	..	..	..
Measles	0.13	..	..	..	..	..	..	..	..	.	..
Scarlatina	0.07	0.04	..	..	..	..	..	..	..	..	..
Typhus	0.01	0.04	0.07	0.15	0.03	0.03	..	..	..	..	..

The various causes of blindness, as given in Table VII., will now be considered individually, with such remarks and deductions as are of general interest.

(1.) *Ophthalmia neonatorum* furnishes 10.876 per cent. of the blind, a larger proportion than any other single cause—which in itself invests it with grave importance; and this importance is greatly enhanced, when it is considered that blindness from this cause means an entire life of blindness; that this disease can be practically prevented by proper prophylactic measures; and further, that even after it is developed, prompt, energetic, and appropriate treatment will usually bring it to a successful termination, without impairment of sight. The simple measure of washing the eyes of all infants with warm water as soon as they are born, and instilling a few drops of a two per cent. solution of silver nitrate into the conjunctival sac, and subsequent attention to cleanliness, would almost banish this disease from our lists, as has been lately proven in the Maternity Hospital in Vienna, and other similar institutions. Ophthalmia neonatorum is almost always caused by the irritating discharges from the vagina, which gain access to the eye either during birth, or, later, by the careless handling of the infant with unwashed hands which have been about the vulva. And it should be borne in mind that these discharges may produce inflammation in any conjunctiva with which they come in contact. Furthermore, the contagiousness of conjunctival discharges should never be overlooked, and this action should always be explained to those who have to deal with any form of conjunctivitis. As a rule, the contagious material from a mild form of conjunctivitis will produce a slight attack in another eye, and *vice versa* for virulent forms. Yet this is not always the case.

(2.) *Trachoma and blennorrhœa of adults*, with a percentage of 9.492, come next in order of importance. *Trachoma* occurs chiefly in the lower walks of life, where, from necessity or indifference, there is overcrowding, bad ventilation, lack of cleanliness, and a general disregard of the laws of hygiene. It is often seen in the poor and neglected of our city population, in the crowded barracks of military camps, and in the confined quarters of northern latitudes. Its development is favored by low and damp localities, on the one hand, and by dry and sandy districts on the other. The contagiousness of the secretion is also an important element in the spread of the disease in crowded quarters. The presence of trachoma, even in a mild form, renders an eye very prone to take on an active form of inflammation (blennorrhœa), which will assume epidemic character if conditions favor its spread, as is seen in Egyptian or military ophthalmia. Once developed, trachoma becomes always an obstinate, and often a serious, disease; hence prophylactic measures against it are of the utmost importance, and they are to be found in a correction of the sanitary conditions referred to. Its local treatment should be prompt, energetic, and persistent.

Blennorrhœa of adults, may arise from the same conditions that produce trachoma, and it is often an outgrowth of the latter. It is frequently—in fact usually—the result of contagion. The discharge from any form of conjunctivitis, as also leucorrhœal or other irritative discharges, gaining access to the eye may produce the disease. The observance of care and cleanliness, with proper regard to hygiene, would cause both of these diseases to disappear, and appropriate treatment would cure most cases, even after the disease has developed.

(3.) *Diphtheritic Conjunctivitis.*—Diphtheritic and membranous ophthalmia are sometimes caused by direct infection of the conjunctiva by diphtheritic material from the throat of another person, while in other cases the diphtheritic process creeps up the nasal duct from the nose, and thus reaches the lining membrane of the eye. But in the majority of cases of diphtheritic ophthalmia the disease is a local one, in which the inflammation takes on this special form. No doubt there is often something peculiar in the patient's health, or in the state of his eye-tissues, which gives a proclivity to this particular pathological process. These cases are, for instance, seen with particular frequency after measles, and less commonly during or after scarlet fever, and are more likely to occur in children than in adults. The existence of old, granular disease of the conjunctiva also gives a strong tendency to a diphtheritic type of inflammation, and the same tendency is seen sometimes in a well-marked degree in ophthalmia neonatorum, and in gonorrhœal ophthalmia.

(4.) *Diseases of the Cornea.*—This furnishes rather a large contingent of blind, and it is not to be wondered at when we consider that transparency and regularity of curve of this membrane are essential to good vision. Keratitis, in its various forms, may leave opacity sufficient to cause blindness; and the same is true of superficial ulceration; while deeper ulceration may lead to prolapse of the iris, displacement or obliteration of the pupil, etc., and all are, at times, liable to be followed by softening of the cornea, with development of staphyloma, etc. Hypopyon keratitis furnishes a larger number of blind than all other corneal affections put together. Kerato-conus and kerato-globus are sometimes causes of blindness.

(5.) *Irido-choroiditis, Cyclitis, Iritis.*—The different diseases enumerated under this heading are placed together, *first*, because they often combine; and, *second*, because the structure involved—the uveal tract—is common to each of the several anatomical parts designated. The term *uveitis* is often and advantageously employed to describe, collectively, inflammations in these parts. *Iritis*, uncomplicated, rarely causes blindness; yet it may do so if the pupil becomes glued down to the lens, and the pupillary space becomes blocked with exudation (*occlusion of pupil*). Both this condition and that of *exclusion of pupil* (complete posterior synechiæ) are very apt to be followed by *secondary glaucoma*. More frequently synechiæ from previous inflammation cause recurrent attacks of iritis; and the inflammatory process, extending to the choroid, or to the ciliary body, or to both, gives rise to opacities in the vitreous, and later to detachment of the retina, cataract, etc. The trouble may begin in the choroid, or, less frequently, in the ciliary body, and, extending to other parts, or remaining in either locality, may cause blindness in the same way.

(6.) *Choroiditis Myopica* (6) *and Detachment of the Retina* (11) will be treated of together under the head of the latter, both being considered as effects of myopia.

(7.) *Choroiditis, Retino-choroiditis.*—The choroid and retina are so intimately associated that it is difficult to have an affection of one of these structures without involvement of the other. Syphilis, acquired or inherited, is the usual cause; and blindness is produced by the formation of opacities in the vitreous, and disturbance or destruction of the retinal elements.

(8.) *Retinitis Pigmentosa, Acquired.*—Though this affection may be developed at almost any period of life, it

cannot be considered an acquired disease, for it occurs in particular groups of individuals who, from hereditary tendencies or from consanguineous marriages, show congenital deficiencies in this and in other ways. Such cases are hopeless; and even when the disease is recognized in an early stage little or nothing can be accomplished in the way of treatment.

(9.) *Retinitis Apoplectica.*—The chief significance of this disease is the index which it furnishes of the condition of the blood-vessels in the brain; for it is usually but a precursor of similar trouble within the cranium.

(10.) *Neuro-retinitis*, as an idiopathic affection, is almost unknown. It usually occurs as an accompaniment of some other disease—as syphilis, Bright's disease, intracranial disease, pregnancy, cardiac disease, etc., but as these diseases are specially considered as sources of blindness further on, we are reduced to very narrow limits. It must be admitted that cases of neuro-retinitis are occasionally seen without apparent cause. And it is probable that such vague causes as prolonged exposure of the eyes to very bright light, with great heat, as from the glare of a furnace, or the reflection of the sun from the waters of the tropics, or from excessive use of the eyes by strong, artificial light, may produce the disease, and thus lead to blindness.

(11.) *Detachment of the Retina and* (6) *Choroiditis Myopica.*—Myopia, the cause common to each of these conditions, is of great importance, and merits careful consideration. It may be said to be an outgrowth of civilization and education, and it may be taken as an index of the studious habits and of the close eye-work of a people. In this present busy age of progress and competition, which calls for work at high pressure, and necessitates the forcing process as soon as school-days are begun, there are many causes at work which serve to swell the ranks of myopes, and to lay the foundation for its future increase. The long hours of confinement in the school-room, and the lack of proper out-of-door exercise and fresh air, tend to cultivate sedentary habits, and to lessen the resisting power of the tissues of the body. And the close application of the eyes at near work, with badly constructed desks and insufficient illumination, which necessitate stooping over the pages and straining the eyes, bring on congestion of the fundus of the eye, and thinning and bulging of the sclera at the point of least resistance—the posterior pole—and the consequent development of myopia. This condition, once produced, is increased by a continuation of the causes which induced it; and in unpromising subjects, even the removal of these does not put a stop to it.

The development and increase of myopia during school-life are nowhere better shown than in the following table, taken from Fuchs and prepared by Cohn. The village school corresponds to our lowest grade, and then follow in regular sequence the higher grades, until the last or university course is reached:

TABLE IX.

	Percentage of myopia.	Degree of myopia.
Village school	1.4	$^1/_{24\cdot4}$
Elementary school	6.7	$^1/_{22\cdot7}$
Intermediate school	10.8	$^1/_{21\cdot9}$
High school	19.7	$^1/_{19\cdot6}$
Gymnasium (college)	26.2	$^1/_{18\cdot7}$
University	59.0	$^1/_{12\cdot2}$

It was furthermore noted that the percentage of myopia increased in each school from class to class. Among theological and medical students, whose term of study is prolonged beyond the ordinary university course, the percentage of myopia is still further increased, reaching in the case of theological students seventy-eight per cent. And in reference to confinement and in-door life on the one hand, and out-of-door life and exercise on the other, Erisman found the percentage of myopia in resident scholars to be forty-two per cent., and in day-scholars to be thirty-five per cent. Dor found even a greater difference—thirty-three per cent. against eighteen per cent.

Myopia abounds among studious people, and is almost unknown among the ignorant and illiterate. It is not congenital, yet the tendency to its development is certainly transmitted from parent to child. The prophylactic measures against myopia are of the utmost importance. First and foremost are: A proper amount of out-of-door exercise during school-life; well ventilated school-rooms, with good illumination, properly constructed desks, so that the light will fall to best advantage upon the page, and avoidance of the habits of stooping or bending the head over the work, and of holding objects close to the eyes. After the development of myopia, much can be done for its relief by the use of atropine and the wearing of properly selected glasses. It should be remembered that myopia fosters sedentary and studious habits; and it at times becomes advisable to discontinue the use of the eyes for near work altogether; and it not infrequently falls within the province of the physician to decide upon the child's future mode of life and employment.

A few cases of myopia with choroiditis occur independently of the causes here ascribed to it; yet they are so infrequent that they may be left out of consideration. And, too, detachment of the retina is sometimes seen in eyes that are not myopic; but it rarely occurs in such as a primary affection, and when secondary to some other pathological lesion, that, and not the detachment, is the cause of blindness.

(12.) *Glaucoma.*—The importance of this disease, as indicated by its quota of blind, is forcibly increased, when its usual amenability to treatment is considered. While a well-marked case of glaucoma presents unmistakable symptoms of the disease, which it would be unpardonable to overlook, there are other cases which are obscure and misleading. The very fact of this uncertainty should, however, put us upon our guard; and there are few cases, indeed, which would run the gauntlet of careful examination and close observation. Once recognized, prompt and energetic treatment is indicated; and there is no operation in the whole range of surgery that affords more brilliant results than does iridectomy in cases of acute glaucoma. Sclerotomy and eserine have their spheres of usefulness; and stretching the external nasal nerve has recently been much lauded in the treatment of certain obstinate forms of glaucoma. Unfortunately the more obscure cases attract but little attention until the disease is far advanced, and medical advice is sought only after serious and permanent impairment of sight comes on. A more thorough knowledge of the disease and greater familiarity with its symptoms by the general practitioner will not only insure its more prompt recognition, but will lead the laity to a better understanding of the affection, and cause greater care in the observance of eye symptoms. A few cases of glaucoma are strongly allied to optic-nerve atrophy, and these are very unfavorable.

(13.) *Idiopathic optic nerve atrophy* occurs most frequently in subjects who have inherited a tendency to nervous disorders. It is often a precursor of spinal cord or of cerebral disease; and as the length of time which may intervene between the development of optic atrophy and central changes is often considerable, the diagnosis is usually difficult and uncertain. The disease is one of the most obscure that we have to deal with, and the prognosis is unfavorable. It is much more frequent in men than in women.

(14.) *Tumors of the Eye and its Surroundings.—Malignant diseases*, as glioma of the retina, sarcoma of the choroid, of the ciliary body, and of the iris, and epithelioma or lupus of the conjunctiva, or of the cornea, may produce blindness through destruction of the globe by their own growth; yet their chief importance is in their danger to life. Cysts of the iris may cause blindness by increase in size, if not removed.

Gummata of the ciliary body and of the sclera may also produce blindness in the same way. Other tumors

of the eye rarely cause blindness. Tumors arising from parts adjacent to the eye may produce blindness, directly by extension of the disease to the globe, or indirectly by pressure effects upon the globe or optic nerve, as is seen in vascular and cystic tumors of the orbit, and in tumors or distention of the frontal, ethmoidal, nasal, or maxillary sinuses.

(15.) *Unclassifiable.*—The percentage here given may be taken as a fair example of the proportion of the blind which present such complicated conditions as to preclude classification.

(16.) *Direct Injury of the Eyes.*—The more important proportion of these cases occur in individuals whose labor necessitates exposure of the eyes to flying bits of metal or stone, as machinists, workers in stone, miners, etc., and in those who have to deal with explosives, as in blasting, the manufacture of explosive materials, etc. The use of protective glasses, preferably of mica, which combines perfect transparency with considerable strength, is a measure that would afford much protection to the eyes, though it has been but little adopted by workmen exposed to these dangers.

A certain number of cases occur from unavoidable and unforeseen accidents, and of these, it is unnecessary to treat.

(17.) *Unsuccessful Operations.*—The percentage here furnished certainly appears small, when it is considered that many eye operations are attended with considerable risk to the eye, even in the hands of the most accomplished operators. Cataract extraction—the most important operation in ocular surgery, and at the same time the most formidable—is accountable for most cases of blindness, from operative measures. Performed late in life, when the process of repair is impaired by age and often by disease, it is to be wondered that the proportion is not larger.

(18.) *Injuries of the head* produce blindness through lesions of the optic nerve, at or about the optic foramen. It is known that blows upon the head may cause fracture of the bones about the apex of the orbit, or at the optic foramen; and blindness ensues from injury to the optic nerve—immediately if the injury be severe, and more slowly if dependent upon secondary degenerative changes (atrophy). Meningitis following injuries of the head may cause optic neuritis or atrophy and blindness. And injuries of the angular gyrus may produce blindness.

(19.) *Traumatic Sympathetic Ophthalmia.*—This is one of the most important of eye-diseases, and, because of its insidious character and its intractable and uncertain course, merits the utmost care in its consideration at the hands of ophthalmologists, and general practitioners as well. Resulting, as it does, from previous mechanical injury which has greatly impaired or entirely destroyed the fellow-eye, its treatment involves great responsibility. And as it not infrequently happens that the sympathizing eye is ultimately left in a worse condition than the exciting one, advice should be well and intelligently considered. It may appear within a few weeks, and it may not develop for years; and while its prodromata may extend over periods varying from weeks to months, it sometimes comes on unannounced, and quickly leads to blindness. Arising at times from wounds, apparently trivial, in the ciliary region, it occasionally fails to appear after extensive injury to this, the vulnerable zone. Treatment of the disease after it has developed is of course important, and while it is often unsatisfactory, it is always productive of great good. The measure above all others to be adopted is prophylaxis; and this includes the proper care of the primarily injured eye, as well at the time of the injury as later on; and this of course involves the question of enucleation. This is an important problem, and there are many points to be carefully considered before a conclusion is reached. It may be stated as a cardinal point, however, that an eye so seriously injured in the ciliary region as to preclude the possibility of retention of sight, should be promptly removed; for such an eye is not only a useless organ, but is a source of constant menace to its fellow.

(20.) *Diseases of the Eye from Syphilis.*—Syphilis is a prolific source of eye-disease, and may cause almost any form of it. The *inherited* form of syphilis, through defective development or inflammation of the several parts of the eye during intra-uterine life, may cause blindness. And abnormalities in the osseous development of the orbit or of the skull may, through pressure upon the visual tract, cause optic neuritis or atrophy and blindness. Diffuse (parenchymatous) keratitis—a disease of early life—is also occasionally productive of blindness. Either the *inherited* or the *acquired* form of syphilis may cause blindness through kerato-iritis, iritis, irido-cyclitis, irido-choroiditis, choroiditis, retino-choroiditis, and optic neuritis or atrophy. In tertiary syphilis, gummata—affecting by preference the sclera or the ciliary body—may produce destruction of the eye. And the periosteal or bony lesions of this stage may cause, through participation, or by their pressure effects, disease of the eye or of its conducting apparatus, which leads to blindness. An early recognition of the specific taint, and prompt and energetic measures against it, constitute the sheet-anchor of success in all diseases dependent thereon.

(21.) *Gonorrhœal Conjunctivitis.*—This is a most virulent form of purulent ophthalmia, due to inoculation of the conjunctiva with the discharge from a specific urethritis or vaginitis. The material is conveyed to the eye by accident or by carelessness, through unwashed hands in persons with gonorrhœa, or in those treating it, and the use of towels or of linen which have become contaminated. Perfect cleanliness and care, observed by gonorrhœal subjects and by their attendants and associates, would expel this disease from the category of eye affections.

(22.) *Scrofulous Diseases of the Eye.*—The strumous condition is a fruitful source of eye-disease, yet the diseases to which it most frequently gives rise—ophthalmia tarsi, phlyctenular troubles, etc.—seldom cause blindness. One of its diseases, however,—cyclo-keratitis—is a most serious disease, and often produces blindness. It was first described by Dalrymple, and is sometimes spoken of as Dalrymple's disease. It is fortunately rare. Lupus is usually considered a strumous disease, and this may lead to destruction of the eye—whether attacking the eye primarily, or involving it secondarily.

(23.) *Irido-choroiditis with Meningitis.*—This disease is commonly spoken of as metastatic choroiditis, and is caused by an extension of inflammation from the head to the eye in simple meningitis, or, as is more frequently seen in cerebro-spinal meningitis, by metastasis. The disease usually destroys the eye, and treatment is, ordinarily, unavailing.

(24 and 25.) *Atrophy of the Optic Nerve* (*Cerebral and Spinal*).—It is often difficult, and sometimes impossible, to locate the lesion upon which optic nerve atrophy depends, and it will be convenient to consider these two forms together. According to Galezowski, who tabulated 166 cases of optic-nerve atrophy, about fifty per cent. are due to diseases of the brain and spinal cord; thirteen per cent. are traumatic; nine per cent. are due to alcoholism; eight per cent. to syphilis, and the remaining causes are of the most varied kind. And according to Von Graefe, about thirty per cent. of cases of primary atrophy of the optic nerve are due to spinal disease.

Cerebral optic-nerve atrophy may be consecutive to optic neuritis (of central origin), or it may follow lesion of the chiasm, of the cerebral centres, or of the cortex about the angular gyrus, or it may be caused through pressure upon the nerve by exostosis, tumor, or aneurism; narrowing of the optic foramen by hyperostosis, or by pressure upon the chiasm from distention of the third ventricle. Meningitis, chronic or acute, may also cause atrophy without recognized neuritis, etc. *Spinal atrophy* occurs with locomotor ataxia, of which it may be the earliest symptom; or it may, as is often the case, come as a late manifestation of the disease.

(26.) *Atrophy of the Optic Nerve, or Neuritis after Hæmatemesis.*—Loss of blood is occasionally followed by affection of vision, which may be temporary or permanent It is with the latter that we have to deal, and this usually depends upon either neuritis or atrophy. Clinical ex-

perience has taught that hæmorrhages from the gastro-intestinal tract cause disturbance of vision more frequently than hæmorrhages from other localities (thirty-five per cent). The connection between the loss of blood and disease of the optic nerve has so far received no satisfactory solution. The same connection probably exists between *atrophy of the optic nerve after bleeding from piles* (27), and *after dysentery* (28).

(29.) *Atrophy of the optic nerve after vomiting* is rare, and its connection is obscure. The straining and consequent congestion may produce retro-ocular hæmorrhage, or serous effusion; or it may be due to the connection which exists between the stomach and the corpora quadrigemina.

(30.) *Optic nerve atrophy after facial erysipelas* is usually caused by an extension of the cellulitis to the tissue of the orbit, and the resulting damage to the trunk of the nerve.

(31.) *Atrophy of the optic nerve with insanity.*—Atrophy sometimes occurs among the insane, and most frequently in subjects of general paresis—though it sometimes occurs in dementia and in other forms of insanity. It is a degenerative change, associated with similar lesions in the central nervous system.

(32.) *Atrophy with Epilepsy.*—It does not appear that idiopathic epilepsy has connection with any form of eye-disease. It is only in such cases as are dependent upon gross intracranial lesions that changes are observed in the disk, and the atrophic changes here differ in no way from those seen in the usual forms of brain disease.

(33.) *Retinitis nephritica* occurs in about twenty-five per cent. of cases of chronic Bright's disease. It is more important as a means of diagnosis than as a cause of blindness, for not infrequently it is the first symptom which leads to a detection of disease of the kidney. It rarely causes blindness, however, in spite of the marked pathological changes that are noticeable in the retina, and often in the optic nerve.

(34.) *Diseases of the Eye from Typhus.*—Loss of sight has been many times observed during convalescence from typhus fever, and, subsequently, optic-nerve atrophy has usually been found. In some of these cases cerebral symptoms have been observed, and in others there was none. Keratitis is sometimes seen, and blindness may be one of its consequences.

(35.) *Blindness from measles* may be due to optic neuritis, or it may result from neglected diseases of the external eye, *i.e.*, conjunctivitis, keratitis, etc.

(36.) *Diseases of the Eye from Scarlatina.*—The frequency with which renal disease accompanies scarlet fever renders affections of sight not very rare consequences of the disease. Yet neuro-retinitis does occur without the presence of renal disorder. Atrophy of the optic nerve may also be the result of scarlatina. In malignant cases sloughing of the cornea has been observed, and in other cases keratitis may produce blindness.

(37.) *Diseases of the Eye from Variola.*—Variola may cause neuro-retinitis, or atrophy of the optic nerve; but its chief danger is from diseases of the external eye, almost any part of which may be the seat of the eruption. The most dangerous seat is the cornea, where ulceration often leads to blindness. Iritis has also been observed. Important as the local treatment of these disorders may be, the prophylactic measure of vaccination should supersede them all, and thus prevent entirely the disease upon which they depend.

(38.) *Diseases of the Eye from Heart Trouble.*—The most frequent cause of blindness from heart disease (valvular) is the so-called embolism of the central artery of the retina. This is usually monocular, but sometimes both eyes are affected. Thrombosis of the central vein of the retina behind the eye, in association with disease of the heart, may also produce blindness. In ulcerative endocarditis retinal hæmorrhages often occur, and sometimes panophthalmitis is observed.

(39.) *Diseases of the Eye from Childbirth or Pregnancy.*—In pregnancy we are liable to have albuminuric retinitis, and, following childbirth, we may have metastatic choroiditis, or retinal hæmorrhage; and cases of atrophy of the optic nerve are sometimes dependent upon lactation.

(40.) *Intoxication Amaurosis.*—Under this head are included cases of blindness resulting from the abuse of certain noxious agents, chief among which are alcohol and tobacco. It is claimed that the free and long-continued use of either of these substances not infrequently leads to a form of optic-nerve atrophy possessed of certain distinctive peculiarities. There seems to be good reason for attributing such to alcohol, but the reasons in favor of tobacco are not so strong.

(41.) *Blindness from Diseases of the Orbit.*—Inflammatory processes in the orbit, whether in the cellular tissue or in the periosteum or bone, may cause either simple atrophy of the optic nerve or neuritis and consecutive atrophy. With much swelling of the orbital tissue there is danger that the nutritive supply of the globe may be cut off by pressure, and that the inflammation or sloughing which results may produce blindness. Tumors of the orbit may act as inflammatory products, or, the disease extending to the eye, may directly cause destruction of this organ.

An important matter in the consideration of the causes of blindnesss, is the proportion composed of those whose origin is unavoidable, and the course of which is beyond control. If arranged under the headings of *Preventable*, *Probably preventable*, and *Unpreventable blindness*, we are at once struck with the large number included under the *first* and *second* headings, and the small proportion embraced under the *last*. Absolute accuracy in this arrangement is, of course, not claimed, but it will serve the purpose of illustrating the large amount of blindness arising from avoidable causes, and such as are amenable to treatment.

It may be of interest to state that the first institution for the blind was founded in Memingen, by Weef VI., in 1178: the second in Paris, by St. Louis, in 1260; the first for the employment of adult blind was opened in Edinburgh, by Dr. Johnston, in 1793. There were, in 1873, 148 institutions for the blind in the world.

TABLE X.

Preventable causes of blindness.	Per cent.	Probably preventable blindness.	Per cent.	Unpreventable blindness.	Per cent.
Ophthalmia neonatorum	10.876	Diseases of the cornea	4.034	Diseases of the cornea	4.034
Trachoma and blenorrhœa	9.492	Direct injuries of the eye	2.017	Direct injuries of the eye	2.017
Diphtheritic conjunctivitis	0.356	Unsuccessful operations	1.978	Tumors of eye and surroundings	0.356
Choroiditis myopica	0.949	Irido-choroiditis, cyclitis, iritis	4.430	Irido-choroiditis, cyclitis, iritis	4.430
Detachment of retina	3.746	Detachment of retina	1.000	Injuries to the head	0.277
Glaucoma	8.000	Glaucoma	0.978	Scrofulous diseases	0.039
Sympathetic ophthalmia	4.509	Unclassifiable	1.681	Unclassifiable	1.681
Gonorrhœal ophthalmia	0.910	Diseases of the eye from syphilis	0.238	Diseases of eye from syphilis	0.238
Diseases of eye from small-pox	2.216	Choroiditis, chorio-retinitis	0.369	Choroiditis, chorio-retinitis	0.738
Intoxication amaurosis	0.039	Idiopathic optic-nerve atrophy	2.000	Idiopathic optic nerve atrophy	5.751
		Optic-nerve atrophy, cerebral	2.000	Optic nerve atrophy, cerebral	4.961
		Optic-nerve atrophy, spinal	0.333	Optic nerve atrophy, spinal	2.000
		Typhus, measles, scarlatina, etc	1.165	Typhus, measles, etc	1.165
				Irido-choroiditis with meningitis	1.424
				Other causes, including 3.835 per cent. of congenital blindness	5.412
	41.093		24.189		34.523

There are certain *irregular forms of blindness* which will be treated of under appropriate headings elsewhere, and it will be necessary to refer to them here only in a general way. The free exhibition of *quinine* or of *salicylic acid* sometimes causes blindness; and it has been observed in rare instances to follow the use of *silver*, of *mercury*, and of *lead*. Prolonged exposure to the fumes of *sulphide of carbon* may produce amblyopia; and the fumes of *osmic acid* may bring about the same condition. The circulation in the blood of a superabundance of *urea* is apt to cause transient attacks of blindness. And in *migraine*, or sick headache, attacks of blindness are not infrequent. The attacks of blindness in the foregoing conditions of the system are usually transient, and perfect recovery quickly returns; yet, if often repeated, permanent impairment of sight may result, which, in some instances, declares itself as a low grade of optic neuritis or atrophy. *Hysterical amblyopia* is a recognized condition. It is temporary and irregular, and is usually attended by other hysterical symptoms. Temporary blindness may occur as the *aura* of an *epileptic attack*. Cases of *word-blindness* have been observed in individuals who could talk and even write, which were dependent upon lesions about the angular gyrus. *Night-blindness* or *moon-blindness*—hemeralopia—is a condition of torpor of the retina, which usually affects those who have been long exposed to bright lights—as sailors or marching soldiers, in the tropics. Insufficient food, either as to quantity or quality, seems also to be a factor in the disease. *Day-blindness*, or *nyctalopia*, is a form of retinal hyperæsthesia which is also usually caused by long exposure to glistening surfaces brilliantly illuminated by the sun. *Snow-*, or *ice-blindness*, is a variety of nyctalopia, though there are with this form usually signs of conjunctival implication. *One-sided blindness*, or *hemianopsia*, which may exist in various forms, is occasionally seen, and it is often of importance in locating intracranial lesions. *Blindness from disuse—amblyopia ex anopsia*—is claimed by many to result from the long-continued disuse of an eye. *Simulated blindness* can usually be detected, yet it is often done with difficulty. *Color-blindness—achromatopsia*—may exist in various forms. It is of great importance, and receives ample consideration elsewhere.

James Lancelot Minor.

BLISTER (Bleb, Bulla; Fr., *Bulle;* Ger., *Blase*).

Definition.—A vesicle of the skin caused by the separation of the cuticle or epidermis from the rete mucosum, and containing a fluid which consists of serum, sometimes mingled with a greater or less amount of blood.

Etiology.—Blisters may be classified in three groups. First, idiopathic blisters, such as are observed in pemphigus, etc.; second, symptomatic, as in erysipelas, herpes zoster, etc., in which the vesicular development is but one feature in the course of an underlying and extensive diseased process, which may pervade the entire system of the patient; and third, traumatic blisters, such as may be observed to follow the application of excessive heat to the surface, or may result from the contact of certain irritating substances to the skin. These substances are called *vesicants*.

The first two varieties of blister—the idiopathic and the symptomatic forms—may be met in conditions of great depression of the vitality of the integument, as in prurigo, chilblain, commencing moist gangrene, etc., as well as during the course of many disorders of the skin or of the general system in which the formation of vesicles is an accident and not a usual accompaniment of the particular disorder.

The third variety is recognized as the direct and immediate result of scalds and burns, and other means of effecting an injurious contact of the surface of the body with excessive heat, as well as the consequence of the exhibition by contact of powerful counter-irritants, such as cantharides, ammonia, mustard, etc.

The group of substances known as counter-irritants embraces the following classes: 1, Rubefacients; 2, epispastics, blistering agents, vesicants properly so called.

Vesicants are agents or substances which produce such a degree of irritation when applied to the skin as to induce an effusion of serum between the cutis vera and the epidermis, leading to the formation of a sac containing fluid, which is called a vesicle. This group also includes the employment of the heated hammer, the moxa, and other measures for the production of a blister upon the surface, by means of heat, for remedial purposes.

The application of a vesicant to the surface of the body usually awakens a series of changes in the tissues of the part, which may be described as follows: There ensues at first a comfortable sensation of warmth, which increases more or less rapidly to a feeling of intense heat, and acute burning pain in the area of skin to which the vesicant has been applied. The surface is raised somewhat above the level of the surrounding skin, and is generally reddened in color. If the part be pressed upon by the finger, the red color immediately returns on removing the pressure. Soon after this, if the vesicant be allowed to remain in contact with the skin, minute collections of fluid may be observed, which are situated beneath the cuticle, and lift it away from the rete mucosum, forming small vesicles, and these, by coalescing, form larger accumulations, or the entire surface to which the vesicant was applied may be occupied by a single large sac of fluid.

A counter-irritant may produce a varying result, according to the condition of the part to which it is applied, and also according to the character of the substance employed. Irritation in one part of the body may affect the function or nutrition of other parts more or less remote from the seat of irritation. In like manner, stimulation of the surface may decidedly influence the circulation of underlying structures.

The effect which is produced by the action of a blister is of two kinds: First, the blood-vessels of the surface are caused to dilate, allowing a more active circulation of the blood through the superficial tissues, thus relieving local vascular tension, and sometimes modifying the circulation of the entire body; this action diminishes, to a certain extent, the congestion or increased vascular pressure in organs or parts lying deeply beneath the surface, and is frequently followed by a marked amelioration of pain and other symptoms referable to a diseased condition of these structures; second, the effusion of serum, which follows the application of a vesicant, is the means of mechanically reducing the absolute amount of material in the affected part, by the withdrawal or removal of a certain quantity of fluid from the tissues, thus relieving the tension in the subjacent structures and diminishing swelling, and softening the textures beneath the surface.

Blisters may thus be of service in congestion of the lungs or brain, or may modify an inflammatory process connected with the serous membranes investing the pleural or pericardial cavities.

All vesicants are primarily rubefacients, and stimulants to the skin. Revulsion and derivation are each a form of counter-irritation, one of which exerts an influence in the immediate vicinity of the disease, while the other is applied to a remoter part of the body, with the view of there arousing a second irritation, in the hope that the original disease may thereby be modified.

Counter-irritants should not be applied directly over an inflamed part, nor to loose and elastic surfaces of skin, such as the scrotum, eyelids, or axilla, nor to the breast during pregnancy.

In feeble persons, or in cases in which the vitality of the patient has been greatly reduced, as after sudden and great loss of blood, in cholera, in the condition of shock, etc., the application of an ordinary vesicant may not be followed by pain, owing to the depression of the vital forces.

The vesicant should not be left too long in contact with the skin, even in the absence of pain, on account of the danger of subsequent sloughing of the integument, which is often followed by a deep and long-standing ulceration, with the ultimate formation of a cicatrix when healing is at length accomplished.

Blisters are not admissible in the care of children when suffering from any low or exhausting form of disease. If

a blister has been in contact with the skin for a proper length of time without producing any perceptible effect, it should be removed lest a slough of the part should follow.

The primary action of a vesicant is that of a *stimulant*, followed by a greater or less degree of depression. The stimulant effect is more transient accordingly as the vesicant is more powerful, and the blister is more rapidly formed. The secondary depression is more or less profound according to the length of time during which the vesicant has been in contact with the skin, the depth to which the irritant action has penetrated, and also, to a certain degree, the state of vitality of the tissues over which it was applied.

A blister, when fully formed, should be opened, by means of a small knife or a needle, at its most dependent part, and the serum allowed to escape. The cuticle is thus brought again in contact with the rete mucosum, and there is little pain or discomfort during the period of healing. In children it is often advisable not to open a blister, as the effused serum is the best dressing for the part, and a new cuticle forms easily and painlessly beneath the unbroken blister.

In certain acute or chronic conditions a succession of small blisters upon the surface over or near the seat of the disease is followed by marked benefit. These are commonly called "flying blisters," and are of small size, and may be frequently repeated, and thus produce a continuous counter-irritant effect. They are best applied in the form of a ring of blistering material, like a corn-plaster, which leaves a small point of uncovered skin in the centre. Flying blisters are often of service in affections of the brain, especially those accompanied by congestion and effusion, as in chronic hydrocephalus and in non-tubercular meningitis. Blisters are often of great benefit in functional disturbances of the nervous system, in which they act as a counter-irritant and as a stimulant. They have been known to stop the spread of erysipelas, though how they thus act is not clearly understood. In cases of effusion in the larger joints, and in the other serous cavities of the body, blisters over or around the part hasten the absorption of the effused fluid. They also accelerate the action of certain medicines, especially those belonging to the class of alteratives, by hastening the metamorphosis of tissue and changing the structure of the parts to which they are applied. The same treatment has been found beneficial in rheumatism. In persistent nausea and vomiting the application of a vesicant to the epigastric region sometimes affords relief when all other means have failed. The pain of pleurodynia is often mitigated or entirely relieved by blistering, and many other pains of neuralgic character are benefited by this means.

When any disease of the kidneys or bladder exists, cantharides should never be employed, on account of the danger from absorption of the irritant constituents of this substance, and the consequent aggravation of the urinary trouble. In acute pericarditis and endocarditis the application of small repeated blisters is often of great service in relieving pain and checking the inflammatory process. Vesicants are frequently useful when the reflex functions of the body are seriously depressed, as in shock; in acute affections which impair the powers of the heart or lungs; in sudden visceral congestions; in collapse, faintness, and in the lethargy produced by alcohol or by narcotics. In some forms of headache, in gastralgia and colic, in the oppression of breathing so often observed in diseases of the heart and lungs, and in cough of reflex origin they are often of great service, as well as in the commencing stages of meningeal inflammation of the spinal cord.

In applying blisters those portions of the cutaneous surface should be avoided which are immediately over superficial bones, or where pressure occurs either from the clothing or from the weight of the body. They should not be employed on surfaces in a state of acute inflammation, nor in high fever.

Whatever means may be employed to produce the effusion beneath the cuticle, the subsequent treatment of the vesicle is pursued with one of two objects: either to render the injury to the parts as transient as possible, and to restore the integrity of the cuticle; or to establish a permanently secreting surface. The former is generally the result which it is desirable to obtain in the treatment of blisters when employed to relieve sudden congestions or acute effusions in the serous cavities, or sudden attacks of pain in the superficial regions of the body. The formation of a permanent secreting surface is generally indicated in chronic inflammations of the deeper structures or organs in which it is desirable to induce long-continued counter-irritation, with a certain amount of local depletion. The inflammatory process is modified by the neighboring counter-irritation, and a tendency to restoration is induced in the diseased organs. There is a limit to the time during which a blistered surface should be kept discharging. When the surface becomes covered with granulations and is elevated and roughened and spongy in appearance, all irritant applications should be discontinued lest an unsightly and uneven cicatrix be produced.

Blisters may be produced by a great variety of methods, as has been intimated in an earlier part of this article. Among the most useful means of inducing prompt vesication are the following: A blister is quickly formed if a pledget of cotton be moistened with strong ammonia water and applied to the skin beneath a wineglass. Chloroform employed in a similar manner is a speedy and safe vesicant. Another most useful method of producing a blister is mustard, either in the form of the commercial "leaves," or simply mixed with cool water and applied to the part desired.

A very elegant vesicatory is made by mingling the active principle of the vesicating substance with collodion, when it may be painted upon the surface, and there produces a blister. In this way cantharides may be applied to almost any part of the body. This is a desirable form for employment in the care of children.

The hydrate of chloral is considered a useful agent for inducing vesication. It is applied by confining the vesicant in crystals beneath a small piece of adhesive plaster. The chloral is not afterward disturbed, the blister healing quickly and perfectly beneath the adhesive plaster.

There is no doubt that the employment of blistering agents in the treatment of disease has fallen into undeserved disuse. This is a matter for regret, as we possess hardly another means, except the abstraction of blood by venesection, which is now also a neglected procedure, of so quickly and radically inducing a change in the physical and physiological condition of limited areas of surface, or extensive parts or organs, as may be achieved by the judicious use of the various vesicants; and it requires no prophetic eye to look forward to the time when this branch of therapeutical medication will be again appreciated by the profession. *Albert N. Blodgett.*

BLOCK ISLAND. This island (Lat. 41° 13′ N., Long. 71° 35′ W.), lying some ten miles out at sea, and situated about midway between Point Judith, on the Rhode Island coast, and Montauk Point, the eastern extremity of Long Island, is, with perhaps the single exception of Nantucket, further distant from the mainland, and consequently more thoroughly exposed to purely maritime influences, than is any other resort lying along the Atlantic coast of the United States. According to "Lippincott's Gazetteer," the length of the island, from north to south is eight miles; its breadth, from east to west varies between two and five miles. The greater part of the island is considerably elevated above sea level. The rocky bluffs lying upon its southern and southeastern shores are said to rise some two hundred feet above the water, rendering this part of its coast exceedingly picturesque and bold in appearance; while an elevation of some three hundred feet is said to be attained in some parts of the interior. The general surface of the island by no means consists, however, of an uniformly elevated table-land, but is decidedly undulating and of uneven configuration. On the eastern shore, where the chief hotels are located, there is

a fine beach for bathing. The facilities for boating and for fishing are also said to be unsurpassed. Besides the meagre account of Block Island contained in the pages of "Lippincott's Gazetteer," the writer has hitherto seen no description of the island, save that contained in the two pamphlets circulated as advertisements of its hotels. In these pamphlets, however, there is to be found a long extract from an account of Block Island as a health resort, written by Dr. H. Holbrook Curtis, of New York, a physician who is in the habit of passing his summers at this seaside resort. The reputation of this gentleman is such as to give the greatest weight to his comments, which are based, moreover, upon personal experience. In this article, published originally in the pages of the New York *Medical Record*, Dr. Curtis bears witness to the exceptional purity of atmosphere existing at Block Island, to the coolness of the place in summer, to the bracing and remarkably tonic, as well as soothing, effect of its climate, and to the decided benefits attainable and attained by a summer sojourn at this spot in cases of nervous prostration, insomnia, malarial poisoning, and in some cases of pulmonary phthisis. The doctor also testifies to the good quality of the water-supply, the comfort of the hotels, and the perfect system of drainage in vogue at the latter. His article also contains a table, showing the temperature at noon for each day of the two months of July and August, 1880, as taken by a gentleman who was staying at the island. Similar tables for those two months during the years 1881, 1882, and 1883, based also upon private observations, are given elsewhere in the two pamphlets already referred to. From the figures of these four tables the present writer has deduced by calculation the following chart, which shows the average noon temperature for July and August, in each of the four years specified (1880, 1881, 1882, and 1883), as also the absolute maximum and absolute minimum noon temperatures, the average maximum and minimum at noon, the absolute and the average range, and also the absolute and the average number of days in each month upon which the mercury rose to 80° F. or above, and upon which it stood at 70° F. or lower, at the hour specified. A glance at this table will show not only the coolness, but also the great evenness of the midday temperature at this exceptionally and truly maritime resort. In conclusion, it should be remarked that over and above the good bathing, fishing, and boating already mentioned, it is said that very pleasant drives are to be had in various directions about the island, and constitute, together with the music, dancing, etc., commonly found at all large summer hotels, another amusement and diversion for the visitors to Block Island. Dr. O. D. Cheney, of Haverhill, Mass., is also quoted in the two pamphlets above referred to, his testimony corroborating that of Dr. Curtis, in respect to the attractiveness of Block Island as a summer resort, as well as to the beneficial effect upon invalids exerted by the climate of the island.

NOON TEMPERATURES AT BLOCK ISLAND.
(July and August, 1880, 1881, 1882, and 1883.)

		Average.	Maximum.	Minimum.	Monthly range.	No. of days on which temperature was at or above 80° F.	No. of days on which temperature was at or below 70° F.
1880	July .	75.5	81.0	70.0	11.0	3.0	4.0
	Aug. .	74.3	82.0	62.0	20.0	3.0	5.0
1881	July .	73.4	80.0	66.0	14.0	2.0	9.0
	Aug. .	72.2	79.0	58.0	21.0	0.0	9.0
1882	July .	74.2	82.0	60.0	22.0	6.0	6.0
	Aug. .	74.4	80.0	68.0	12.0	1.0	6.0
1883	July .	73.8	80.0	65.0	15.0	2.0	6.0
	Aug. .	72.6	80.0	66.0	14.0	2.0	9.0
Average	July. .	74.22	80.75	65.22	15.5	3.2	6.2
	Aug. .	73.87	80.22	63.50	16.7	1.5	7.2

Huntington Richards.

BLOOD. The blood of man and of the vertebrate animals is an opaque fluid, varying in color from a bright scarlet to a dark cherry-red, according as it is taken from an artery or a vein. Received in a vessel and allowed to stand, certain changes take place through which is effected a separation of some of its principal constituents, a sort of spontaneous analysis, which has at all times served as a starting-point for the study of this, the most complex of the animal fluids. The first of these changes is that the blood ceases to be fluid, and assumes a gelatinous consistence, still, however, retaining the form of the vessel containing it. Soon it begins to withdraw itself from the sides and bottom of the vessel, and simultaneous with this retraction is the appearance of a transparent amber-colored fluid which, first exuding in drops, soon covers on all sides the gradually contracting gelatinous mass. The solid portion, which still represents in miniature the internal surface of the vessel, is known as the crassamentum, coagulum, or blood-clot; the expressed fluid as the blood-serum.

TIME OF COAGULATION.—The time between the withdrawal of the blood and its coagulation is variously stated, and this discrepancy is doubtless owing to the fact that different methods of determining the question were employed by each observer. When it is recalled that the coagulation of the blood is influenced by the rate of speed at which it escapes from the blood-vessel, its slow escape accelerating the formation of the coagulum, and *vice versa*, the importance of absolute uniformity in the methods employed is manifest.

Hewson states as the result of his experiments, that "the blood of a dog and of the human subject jellies out of the body nearly in the same time, that is, it begins in three or four minutes, and is completed in seven or eight." Nasse found the time of the first appearance of coagulation in the blood of man to vary between one minute and fifteen seconds to six minutes, the average in men being three minutes and forty-five seconds, and in women two minutes and twenty seconds. The time of the first appearance of exuded serum from the coagulum varied from seven to sixteen minutes, averaging in men eleven minutes and forty-five seconds; in women, nine minutes and five seconds. Vierordt gives as the result of more than two hundred and fifty observations, made at different periods of the day, nine minutes and twenty-eight seconds as the average time of coagulation. Although the time given by Vierordt is longer than that of Hewson or Nasse, yet the method employed in his investigations was such as would be expected to hasten coagulation. He received a small quantity, about two cubic millimetres, of blood in a capillary tube, stirred it repeatedly with a fine white horse-hair, and noted the moment in which a coagulum formed on the hair.

AGENCIES INFLUENCING COAGULATION.—The effect of age upon coagulation, during extra-uterine life at least, appears to be nil. Dr. B. W. Richardson withdrew the blood from a section of the umbilical cord of a child at term, and found that in neither the arterial nor venous blood, which were kept separate, was there any coagulation for the space of twenty minutes. At the end of that time "a feeble clot formed, unattended with the separation of serum." In forty-three experiments by the same observer upon the fœtal blood of various animals, he "never found the blood firmly coagulated," and "never met with anything like a separation of fibrin."

In experiments upon the blood of embryonic chickens, Boll found no appearance of coagulation until the thirteenth day of incubation.

Coagulation is *hastened* by heat—37.7° to 48.9° C. (100° to 120° F.)—by rest, by exposure to the air, by contact with foreign substances, by the reception of the blood in shallow vessels, and by the addition of water in amount less than twice the bulk of the blood. Arterial blood coagulates sooner than venous. The last portions of blood withdrawn from a vessel coagulate sooner than the first. Coagulation is hastened by starvation and other enfeebled states of the system. Within the vessels, during life, it is frequently caused by thickening or roughening of the intima, due to inflammatory or degenerative processes.

Of all the causes which hasten the coagulation of the blood, the most effective is the multiplication of its point of contact with foreign solid bodies. For example, the introduction of a thread or wire will determine the immediate formation of a clot in blood in which, but for this interference, the process of coagulation would have been much longer delayed. The method employed to defibrinate the blood, namely, whipping it with a bundle of sticks or wires, induces speedy coagulation, owing to the repeated contact of the blood with the numerous surfaces of the sticks or wires, as well as with the air, which is intimately mingled with the blood by the operation.

Coagulation is *retarded* by a temperature of 0° C.

Freezing the blood prevents its coagulation, but it will immediately coagulate when thawed; the clot formed is, however, loose and dark, and little or no serum exudes from it.

The addition of strong solutions of certain alkaline and earthy salts will prevent coagulation. Among these are sodium sulphate, and, still better, magnesium sulphate. This is employed in twenty-five to twenty-eight per cent. solution, of which one part is added to six parts of blood, thereby completely preventing coagulation. The same result is obtained by the addition to blood of four per cent. by weight of sodium chloride.

If, after coagulation has been prevented by mixing a salt with blood, water be added to the mixture, a clot will form. This will occur also if the salt be withdrawn from the blood by dialysis. Mr. Gulliver states that some horse's blood which he "had kept fluid with nitre for fifty-seven weeks, readily coagulated when diluted with water."*

Contact with living tissues retards coagulation. This was first demonstrated by Hewson by confining a portion of blood between ligatures. Mr. Gulliver subsequently found, in one of his experiments, that blood confined in this manner in the jugular vein of a dog, was fluid at the end of five hours.

The addition of water in amount greater than twice the bulk of blood retards coagulation.

Exclusion from air retards, but does not prevent, coagulation, since a clot will form beneath oil or mercury. An apparent exception to this rule is that coagulation occurs rapidly in vacuo; but this is due to the bubbling of gas, by means of which the blood is brought more thoroughly in contact with the walls of the vessel containing it.

In inflammatory states of the system, the blood coagulates more slowly than in health, notwithstanding the fact that it is richer in fibrin than normal blood.

In death from asphyxia, narcotic poisons, and prussic acid, the blood is found fluid or imperfectly coagulated after death.

Separate Coagulation of the Plasma.—By artificially retarding the coagulation of the blood, a more complete separation of its component parts is obtained than when it is allowed to coagulate spontaneously. Thus, when blood is received in a long, narrow glass cylinder that has been cooled by a freezing mixture to a temperature of 0° C., and allowed to stand, there appear in it after from one to two hours, provided this temperature be maintained, three distinct layers; the lowest, dark-red and opaque; the next, gray, opaque, and much narrower, occupying about one-fortieth the height of the entire blood column; the uppermost, transparent, yellowish, and occupying almost one-half the entire column.

This uppermost stratum, known as the *Plasma*, represents the fluid in which, before the separation into layers, certain bodies called the red and white blood-corpuscles were suspended. The former of these contain the coloring matter of the blood, and in virtue of their greater specific gravity, have accumulated at the bottom of the column. The latter, being of greater specific gravity than the plasma, and less than the red corpuscles, have arranged themselves in a layer between the two, and form the opaque, gray stratum above mentioned. They are also known as white cells, or leucocytes.

The plasma may be removed and filtered, provided the same low temperature be maintained during the filtration. If the temperature be raised a little above 0° C., the plasma coagulates, and, in so doing, presents the same phenomena as were mentioned under the head of the coagulation of the blood. Serum exudes from all sides of the coagulum, which, in contracting, loses its transparency, and presents us with a colorless clot composed of *Fibrin* only. Fibrin may also be obtained by beating fluid blood or plasma with a bundle of sticks or wires, to which it will adhere in stringy masses. If thus obtained from plasma, the remaining fluid is pure serum; if from blood, there remains behind serum mingled with blood-corpuscles, or *defibrinated blood.*

The Red Blood-corpuscles.—These bodies occupy the lowest stratum of the column of blood in which coagulation has been artificially delayed. They are also known as the red particles of the blood (Hewson), blood-disks, blood-globules, and blood-cells. The term globule is inappropriate, since they are not naturally globular; and since the term cell is usually understood to imply the existence of a limiting membrane, and none such can be demonstrated in these bodies, it should be discarded. Of the remaining terms, disk and particle, they are, *per se*, as appropriate as the term corpuscle; but the adjective corpuscular may be made use of, while the same part of speech, derived from disk or particle, could not be employed. It is therefore largely for the sake of convenience that preference is given to this term.

The red corpuscles in man are flattened circular disks, with rounded edges and depressed centres, averaging 7.74 μ* in diameter ($\frac{1}{3230}$ inch). Their greatest thickness is 1.90 μ (about $\frac{1}{13000}$ inch). Owing to the unequal refraction of light produced by their convex edges and concave centres, it happens that when, under the microscope, their edges are sharply defined, their centre appears dark, and *vice versa.*

In color, viewed singly by transmitted light, they are of a very pale amber hue, so faint as to be perceived with

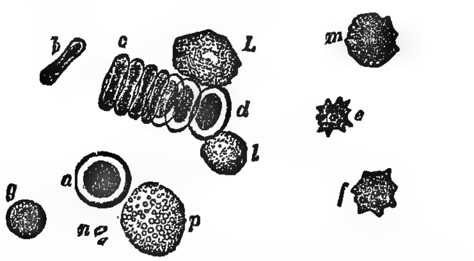

Fig. 428.—(From Ranvier.) Red and White Corpuscles of Man, magnified 1,000 diam. *a*, Full view of red corpuscle; *b*, profile view; *c*, in rouleaux; *d*, three-quarters view; *e*, *f*, *m*, crenated corpuscles; *g*, spherical; *L*, *l*, large and small finely granular white corpuscles; *p*, large coarsely granular white corpuscle; *n*, free granulations.

difficulty by an untrained eye. They are best examined in blood-serum, or dried in a thin layer on a glass slide. This is accomplished by placing a drop of blood upon a glass slide and rapidly drawing another slide obliquely across it, so as to spread out the blood in the thinnest possible film. The desiccation is immediate, and the specimen is permanent. It may be examined either with or without a cover-glass.

The blood-corpuscles, Figs. 428 and 429, are circular in all the mammalia excepting the camel and auchenia, in which genera they are elliptical as they are also in birds, amphibia, and most fishes. Of the latter, a few of the Cyclostomata are known to possess circular corpuscles.

The peculiar optical properties of the human blood-corpuscle have frequently given rise to the supposition that it possessed a nucleus. This is disproved, however, by the facts that while the substance surrounding the nucleus, in nucleated corpuscles—those of birds, reptiles, and fish—gives the same reactions as does the entire human corpuscle; on the contrary, reagents which affect the nucleus

* Note vii. in Hewson's Works.

* The *sign* μ signifies 0.001 millimetre, and is called micromillimetre.

of nucleated corpuscles have no effect whatever upon the human corpuscle.

The color of the blood-corpuscles is due to *hæmoglobin.*

Their consistency has been, and still is, a subject of discussion. Before the time of Hewson they were regarded as liquid bodies, and their shape was thought to be spherical. Hewson, in demonstrating that they were not spheres, but disks, overthrew the theory of their fluid consistency; for it was considered an axiom that one fluid mingled with another in which it is not soluble, will be broken up into globules, provided the latter fluid be in larger quantity. Thus, if a small amount of oil is mixed with a greater amount of water, the oil is broken up into globules. If, on the other hand, the oil is in larger amount, it is the water that assumes the globular form. From these well-known facts Hewson argued that the blood-corpuscles, in virtue of their shape, "*must be solid.*"

Norris has lately shown that this does not necessarily follow. He states that "there are certain combinations of organic substances which, when in solution in water, possess such antagonistic relations to each other that they refuse to remain together in the same solution, and, as a consequence, the one for which the liquid has the greatest affinity will displace the other; nevertheless, the displaced substance will retain to itself a portion of the water in which it was originally dissolved, and, as a consequence of this, it does not come down in a powdery

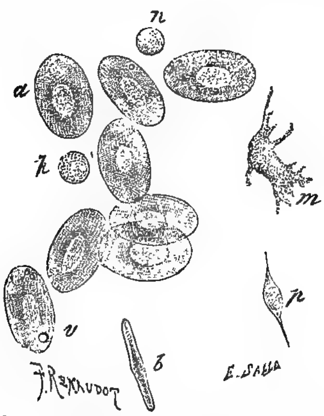

FIG. 429.—(Ranvier.) Corpuscles of Frog. *a*, Full view of red corpuscle; *v*, vacuoles; *b*, seen in profile; *c*, three-quarters view; *n*, *k*, white corpuscles quiescent, *m*, with amœboid prolongations; *p*, fusiform cell, probably from lining membrane of artery.

amorphous form, but in the shape of liquid colloid globules or disks, as the case may be."

By adding powdered gum acacia to a solution of Nelson's opaque gelatin, Norris obtained a precipitate of biconcave disks, represented in Photograph 40 of his work on the blood, the shape of which is identical with that of the red blood-corpuscles.

The extensibility and elasticity of the red corpuscles are extreme, and may be observed in the vessels during life. In the web or mesentery of the frog, they may be observed to yield to the least resistance, and to regain their form the moment the resistance is removed. Outside of the body these physical properties of the corpuscles may be observed by mixing blood with a colloidal substance, such as gelatine or a solution of glue. On allowing the colloid to harden and making thin sections of it, the corpuscles may be observed, under the microscope, entangled in its meshes, and exhibiting every possible variety of form. When freed from pressure, they return to their original shape. The same phenomena are presented by corpuscles which take part in the formation of a coagulum.

Notwithstanding their great elasticity, the corpuscles may be broken into fragments by raising and depressing the cover-glass beneath which they are examined. Each fragment retains the color of the original corpuscle. When nucleated corpuscles are thus treated, the nucleus often escapes entire, while the substance of the corpuscle is broken up.

EFFECT OF REAGENTS.—Since the time of Hewson, hæmatologists have devoted much attention to the study of the effect of various substances upon the blood-corpuscles. Hewson observed the action of water, acids, and alkalies, various salts, alcohol, and urine. His experiments have been frequently repeated, with better methods of observation, and to them has been added many more, of which the principal are mentioned below.

CRENATION.—This peculiar change in the appearance of the red corpuscle has been observed by every one who has looked at blood under the microscope. It consists in an alteration of the contour of the corpuscles, which causes some of them to assume a stellate form, while others appear jagged and uneven, as if a number of minute granules projected from their surfaces in every direction (see Fig. 428). The projection is a passive one, due to retraction of numerous portions of the corpuscle. This phenomenon appears spontaneously in blood withdrawn from the vessels, and is first observed under the microscope in the corpuscles near the edges of the preparation. The appearance is attributed to evaporation of the fluid contents of the corpuscles, and this is undoubtedly one of its causes, though not the only one, as it is occasionally observed after the addition to the blood of water. According to Dalton, it is produced by adding saliva to the blood. It is said to occur more rapidly in the blood of those suffering from febrile diseases.

A number of substances have the effect of depriving the corpuscles of their coloring matter, leaving them pale, round, feebly refracting bodies. Their size is also slightly diminished. The blood becomes lake-colored, and much less opaque. These effects are produced by the addition of water, powdered salts, bile and the biliary salts, ether and chloroform, carbon-disulphide, alcohol in the form of vapor, by freezing and thawing, and by the serum of other animal species.

This decolorizing effect of ether and chloroform is interesting, in connection with the supposed hæmatogenous origin of the jaundice sometimes observed after the prolonged administration of these anæsthetics.

In order to study the action of acids and alkalies, Addison employed solutions of salts or sugar of the specific gravity of blood-serum, to which he added acids or alkalies. He found that, up to a certain point, no effect was produced by either acid or alkali, beyond this point, the blood-corpuscles in the acid mixture became smooth and brilliant, and their refractive power was increased; while the effect of the alkaline fluid was to render them granulated and rough. The same effects may be observed at the poles of a battery discharging weak currents through a portion of blood.

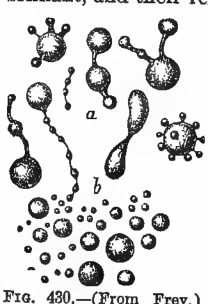

FIG. 430.—(From Frey.) Human Red Corpuscles Heated to 52° C.

The effect of *heat* upon the blood-corpuscles is peculiar. At a temperature of 52° C. (125.6° F.), a number of indentations appear upon their surface, which develop into constrictions. These either become detached at once or, the process continuing, they remain attached for some time to the corpuscle in nodulated threads, that have been compared to strings of pearls. Other corpuscles are beset with knob-like projections, which are attached to them by pedicles of various length. When the projections become detached, they begin a lively molecular movement. The separated particles at first retain their coloring matter, but ultimately yield it to the surrounding fluid (see Fig. 430).

Similar appearances are produced by adding urea to blood, and have been observed in blood extravasations.

The action of salts varies with their degree of concentration. In moderate strength, the effect of sodium sulphate, ammonium chloride, borax, magnesium sulphate, is to render the corpuscles less extensible and elastic, and

to cause them to assume a wrinkled, dentated appearance; in weaker solution their effect is similar to that of water. When the solution is of the same specific gravity as the blood-serum, the corpuscles may remain in it for a considerable time without alteration. On this account they are used instead of serum for diluting the blood for purposes of examination, and especially for enumerating the corpuscles with the hæmacytometer.

Osmic acid preserves the form of the red corpuscle. Norris states, as the result of a series of elaborate experiments with this substance,[1] that its action is confined to the red corpuscles, and in exact proportion to the amount of their hæmoglobin. It not only fixes the form of the red corpuscle and "locks up" its coloring matter, preventing its exudation into the surrounding liquid, but when its action is prolonged it also effects certain changes in its color. These are the result of the conversion of the hæmoglobin into a new body known as methæmoglobin.

Effect of Electricity.—When a portion of blood is included in the arc of discharge of a Leyden jar, and a number of discharges made to traverse it, it becomes lake-colored and transparent, as it does after the addition of water and various other substances mentioned above. Simultaneously with this alteration in the gross appearance of the blood the corpuscles undergo a series of changes that terminate in their becoming colorless, feebly refracting globules. The first stage in the process is an incurvation (Fig. 431, *b*) of the outline of the corpuscle, which proceeds to the formation of a rosette-like body, *c*. This, as the discharges are continued, comes to resemble a horse-chestnut, *d*. Finally, the thorn-like processes disappear, leaving a colored globule, *e*, which ultimately, *f*, yields its coloring matter to the surrounding fluid. The

FIG. 431.—(From Rollett in Hermann's Handbuch der Physiologie.) Effect of Electric Discharges upon the Red Corpuscle.

same effects are produced by induction currents. The constant current, on the other hand, is without any such effect, the only corpuscles presenting any alteration being those in the immediate neighborhood of the electrodes. The positive pole brings about the same alterations in the corpuscles in its vicinity as are induced by the action of acids; the negative pole, those which are caused by the action of alkalies.

The elliptical nucleated corpuscle undergoes a remarkable change on the addition of water. It retains its shape and its even outline, but the nucleus becomes surrounded by either a spheroidal mass or a body with pointed processes, which radiate like the spokes of a wheel toward the periphery of the corpuscle. In either case all the coloring matter seems concentrated around the nucleus and in the processes radiating from it, the remaining portions being homogeneous and of a glass-like transparency. Brücke, who obtained the same appearance with a two per cent. solution of boracic acid, has called the transparent substance Oicoid, the colored, Zooid. The latter is still further distinguished from the former by its capacity of being stained with aniline blue. The separation of the substance of the elliptical corpuscle into Oicoid and Zooid may also be accomplished by ammonium chloride in solution.

STRUCTURE OF THE RED CORPUSCLES.—After the discovery of the animal-cell by Schwann, the red corpuscles were considered to be cellular, like the other ultimate elements of the animal body. This view was shaken by the criticism that a vesicle with fluid contents floating in another liquid would assume any shape rather than that of a biconcave disk. Furthermore, a double contour has never been demonstrated in the corpuscles of any animal. Finally, after the application of those mechanical agencies which exert the most powerful disintegrating action upon the corpuscles, such as freezing and subsequent thawing, electricity, heat, urea, no shreds or folds of membrane have been detected.

It is still debated whether the shape of the corpuscle is maintained by a delicate stroma or framework, the Oicoid of Brücke, in the meshes of which the hæmoglobin is contained. This is the view maintained by Rollett, and ably contested by Norris. The latter regards the corpuscles as fluid, and therefore destitute of a stroma. He considers that their different constituents are combined, molecule for molecule, as are the carbon and iron in steel, and referring to the fact that the iron may be removed from steel, leaving a framework of carbon, argues that we may as well speak of a carbon stroma of steel as of an Oicoid stroma of the red corpuscle.

NUMERATION OF THE BLOOD-CORPUSCLES.—Hæmatologists are generally of the opinion that no method yet devised for estimating the amount of the red corpuscles can compare with that of counting them in a given dilution of blood. The words of Kölliker[2] upon this subject retain their original force. In speaking of the composition of the blood, that well-known authority remarks: "However important it would be to know accurately the proportions of the blood-globules to the plasma, their number and their volume, all researches hitherto have failed, owing to the difficulty of the subject; and even the most recent statements of Schmidt, according to which 47 to 54 parts of moist globules exist in 100 parts of human blood, can only be described as approximative. *One method only can be successful, consisting in the direct enumeration of the globules in accurately determined quantities of blood.*"

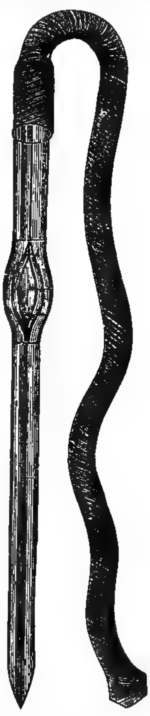

FIG. 432.—Potain's Mixer.

The above was written at a time when Vierordt was making the first counts of blood-corpuscles by a method which, in comparison with the improvements since made upon it, may fairly be called primitive. In spite, however, of the imperfections of his method, Vierordt's conclusions as to the number of red blood-corpuscles are still almost universally accepted. He determined their number to be, for healthy blood (his own), 5,174,000 per cubic millimetre, and the extraordinary amount of labor required to obtain sufficient data on which to found an average, may be inferred from his statement that, in order, by his method, to complete a single enumeration, nearly one week was required.

Vierordt's method consisted in spreading a known quantity of blood, diluted with a gummy solution, upon a slide, allowing it to dry and then counting all the cells by means of a micrometer placed directly upon it. He also diluted the blood with a known quantity of salt or sugar solution, but appears to have always counted all of the corpuscles contained in the mixture. The labor of this method was, as above stated, immense.

Welker, like Vierordt, first obtained a known quantity of blood by means of a capillary tube. He then diluted it with from six hundred to fifteen hundred times its volume of a solution of sodium chloride, took of this solution a small quantity by means of a graduated capillary pipette, mingled it with mucilage upon a cover-glass and allowed it to dry. He then placed the cover-glass upon a stage micrometer ruled with lines crossing each other so as to contain a number of oblong fields, each one of which was numbered so as to facilitate the counting. Welker's modification, it will be observed, is twofold, consisting (1) in the use of a stage micrometer, on which the blood is placed previous to counting the corpuscles, and (2) in counting the corpuscles in a fractional portion of a large dilution, and by an arithmetical process calculating the number of corpuscles in a millimetre of pure blood.

The apparatus of Malassez consists of the mixer (*mé-*

langeur) of Potain and an artificial capillary. The mixer (Fig. 432) is a glass capillary tube, like that of a thermometer, presenting near one of its extremities a dilatation, *d*, that contains loose, within its cavity, a small glass ball, *e*. The longer portion of the capillary tube has a capacity of exactly one-hundredth part of the dilated portion. Two marks, one above (*c*), the other below (*b*), the dilatation, indicate the points that exactly correspond to these proportions The longer portion of the tube terminates in a point To the shorter portion, of which the calibre is somewhat greater, is adjusted a rubber tube. The artificial capillary (Fig. 433) is a fine capillary glass tube fastened to a heavy object-glass. One of its extremities is raised and rounded in such a manner that a rubber tube may be adjusted to it.

The *modus operandi* is as follows · The point of the mixer is placed in a drop of blood and suction applied, by the mouth, to the rubber tube until the blood arrives at the level of the mark separating the long from the dilated portion of the tube. Withdrawing the point of the mixer and cleansing it from any blood adhering to its external surface, it is next plunged in an artificial serum,* and aspiration made until the dilated portion of the tube is filled as far as the mark indicating its superior limit. By this means a mixture is obtained composed of one part of blood and ninety-nine parts of serum. The instrument is now actively shaken, and, by means of the glass ball contained in the dilatation, the blood and serum are thoroughly commingled. This mixture is now introduced into the artificial capillary in the following man-

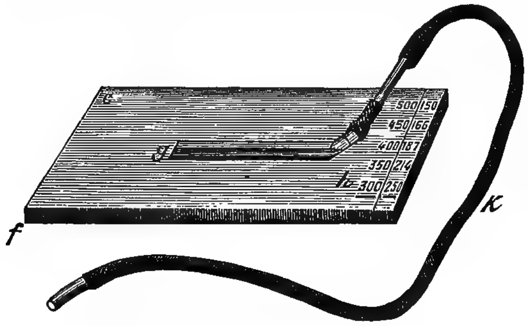

FIG. 433.—Artificial Capillary of Malassez.

ner · The first portion of the blood dilution, namely, that contained in the long portion of the tube, is blown out, after which a drop is placed in contact with the orifice (*g*, Fig. 433) of the artificial capillary. Into this it either penetrates by capillary attraction, or is drawn in by suction through the medium of the rubber tube fastened to the other end of the capillary. This latter is divided into sections by marks upon its surface, each section corresponding to a certain fraction of a cubic millimetre. The microscope is so adjusted that, with a given objective and a given length of the draw-tube, a quadrilateral eye-piece micrometer exactly covers upon a stage micrometer a number of micromillimetres corresponding to one of the sections marked off on the artificial capillary. The corpuscles are now counted in this section, and their number multiplied by the figure expressing the fraction of a cubic millimetre which it represents. This figure is inscribed upon the object-glass to which is attached the glass capillary. This sum is now multiplied by the amount of the dilution, which is one hundred in the case supposed, one part of blood to ninety-nine parts of serum, and the result is the number of corpuscles contained in a cubic millimetre of pure blood.

The apparatus of Malassez requires considerable skill in order to obtain a correct measurement of the serum which is drawn into the mixer after the blood. It is also difficult to cleanse the capillary tubes after using them.

* The artificial serum is composed of a solution, gum arabic sp. gr. 1.020, one volume, and equal parts of solutions of sodium sulphate and sodium chloride having each a sp. gr. of 1.020, two volumes.

The *Hématimètre* of Hayem and Nachet is free from the last mentioned objections. With it, the measurements of blood and serum are taken with separate pipettes, to which are attached rubber tubes with glass mouth-pieces for suction. The measurement of serum is first made and blown into a small glass cup. The blood is then carefully measured by means of a graduated capillary pipette of glass, and blown into the serum, a little suction of the serum and blood mixture back and forth clearing the blood pipette of any adherent corpuscles. It is then rapidly stirred with a glass rod, and before it has time to settle, a drop of the mixture is placed upon a glass slide upon which is cemented a glass cell with a circular opening, one centimetre in diameter, the cell being one-fifth millimetre deep. The eye-piece of the microscope contains a micrometer ruled in squares, and the draw-tube is so adjusted that, with a given objective, one side of the large square measures exactly one-fifth millimetre upon a stage micrometer. The large square is subdivided into sixteen smaller ones in order to render the counting easier. It is manifest that the number of corpuscles contained in the large square represents the number contained in one-fifth millimetre cube, or in the one hundred and twenty-fifth of a cubic millimetre. Therefore, to ascertain the number of corpuscles in a cubic millimetre of

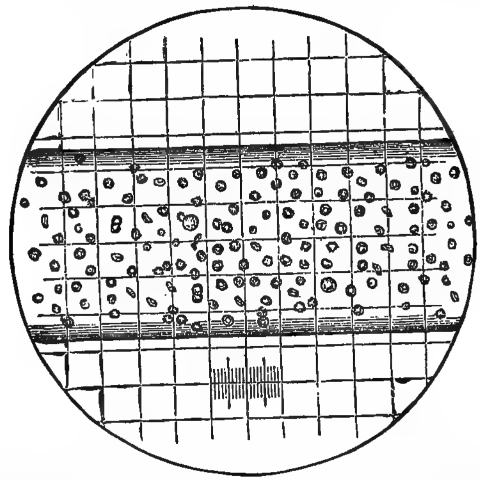

FIG. 434.—Artificial Capillary as it appears under the microscope, by 100 diameters. (From Ranvier.)

pure blood, the number obtained must be multiplied by 125 plus the amount of the dilution. For example, a dilution commonly employed is that of 250 parts of fluid to one of blood (2 c.mm. to 500 c.mm.), and in that instance the number of corpuscles contained in the space covered by the square micrometer, which represents one-fifth millimetre cube, must be multiplied by 125 × 251, or, in one process, by 31,375. In order to approach accuracy, from five to ten squares should be counted and the average taken.

A still more convenient instrument, in many respects, is the *Hæmacytometer* of Gowers.

The following description of the instrument and its use, is taken from an article by Dr. Gowers in *The Lancet* for December 1, 1877 :

"The hæmacytometer consists of (1) a small pipette, which, when filled to the mark on its stem, holds exactly 995 c.mm. It is furnished with an india-rubber tube and mouth-piece to facilitate filling and emptying. (2) A capillary tube marked to contain exactly 5 cubic mm., with india-rubber tube for filling, etc. (3) A small glass jar in which the dilution is made. (4) A glass stirrer for mixing the blood and solution in the glass jar. (5) A brass stage-plate carrying a glass slip, on which is a cell, one-fifth millimetre deep. The bottom of this is divided into one-tenth millimetre squares. Upon the top of the cell rests the cover-glass, which is kept in its place by the

pressure of two springs proceeding from the ends of the stage-plate. . . .

"The mode of proceeding is extremely simple: 995 c.mm. of the solution are placed in the mixing jar; 5 c.mm. of blood are drawn into the capillary tube from a puncture in the finger, and then blown into the solution. The two fluids are well mixed by rotating the stirrer between the thumb and finger, and a small drop of this solution is placed in the centre of the cell, the covering-glass gently put upon the cell and secured by the two springs, and the plate placed upon the stage of the microscope. The lens is then focussed for the squares. In a few minutes the corpuscles have sunk to the bottom of the cell, and are seen at rest on the squares. The number in ten squares is then counted, and this multiplied by ten thousand gives the number in a cubic millimetre of pure blood. . . .

"The number per cubic millimetre is the common mode of stating the corpuscular richness of the blood, but by employing this dilution, and squares of this size, a much more convenient mode of statement is obtained. Taking five million as the average per cubic millimetre for healthy blood, the average number in two squares of the cell is one hundred. These two squares contain .00002 c.mm. of blood, and it is proposed to take this quantity as the 'hæmic unit.' The number per hæmic unit, that is, in two squares (ascertained by counting a larger number, ten or twenty, and taking the mean), thus expresses the percentage proportion of the corpuscles to that of health, or, made into a two-place decimal the proportion which the corpuscular richness of the blood examined bears to healthy blood taken as purity. This is a much more simple method than any hitherto used. The proportion of white corpuscles to the red, or their number per hæmic unit, is best ascertained by observing the number of squares visible in the field of the microscope, and noting the number of white corpuscles in a series of ten or twenty fields. The number of red corpuscles corresponding to the ten or twenty fields is easily computed, and thus the proportion of white to red is ascertained. The normal *maximum* of white per two squares (hæmic unit) is three."

The great advantage of Gowers' instrument, besides the ease of the calculation and the facility with which percentages are reckoned, is that it can be used with any objective or eye-piece without previous adjustment of the draw-tube.

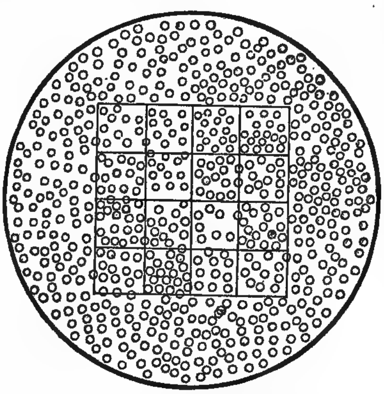

FIG. 435.—Appearance of the Globules with Hayem and Nachet's Instrument.

For examining the blood of anæmic individuals, I prefer it to any other instrument, but in dealing with rich blood, it is not at all uncommon to meet with sixty and, occasionally, seventy corpuscles in one of Gowers' squares (Fig. 436); and under such circumstances it requires the greatest care and patience in order to avoid mistakes, especially when the corpuscles are evenly distributed. When they assume an arrangement into wreaths or lines, the work is rendered much easier; but when, as frequently happens, more than sixty corpuscles are evenly distributed in one of Gowers' squares, count after count may be made of them, with each time a different result. The best that can be done under such circumstances is to keep on counting the corpuscles in the same square until two results agree, at the end of which time the observer is glad enough to accept this number as probably correct.

In my own observations I have used a combination of Gowers' pipettes with Hayem and Nachet's cell and eye-piece, which I think possesses advantages over any single instrument. In the first place, the smaller squares (Fig. 435) of the eye-piece micrometer of Hayem and Nachet render the counting of the corpuscles a much easier task; and secondly, the Gowers' dilution makes the subsequent calculation more simple. With this combination the average number of corpuscles in one of the large squares, and I always take an average of at least five squares, is multiplied by 25,000—a much simpler process than multiplying by 31,375.

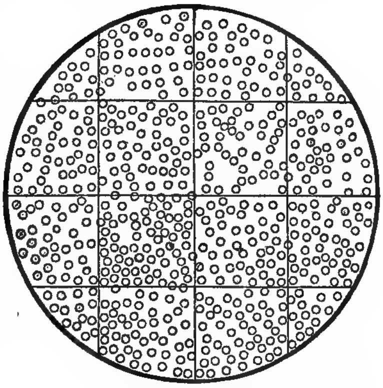

FIG. 436.—Appearance of the Globules with Gowers' Instrument.

Thoma and Zeiss[3] have made use of a combination composed of the *mélangeur* of Potain, and a cell ruled on the bottom in squares, like that of Gowers. One cubic millimetre is divided into four hundred squares, each of which is, of course, 0.05 mm. square The depth of the cell is 0.1 mm. Four of the squares represent 0.001 of the diluted blood, which, with the dilution of 100 employed, represents 0.00001 c.mm. of pure blood.

Abbe, by applying the theory of probabilities to the apparatus used by Thoma and Zeiss, has arrived at the following conclusions:

When four squares are counted, containing in normal blood about fifty corpuscles, there is a probable error of ten per cent. By counting sixteen squares, containing about two hundred corpuscles, the probable error is reduced to five per cent., and a deviation of ten per cent. has a probability of only one-fifth. By counting one hundred squares the probable error is reduced to two per cent., and a deviation of four per cent. has a probability of one-fifth; one of six per cent. a probability of one-twenty-third; one of ten per cent. is only to be expected once in fourteen hundred cases. By counting all the four hundred squares the probable error is reduced to one per cent., and a deviation of four per cent. only is to be expected once in one hundred and sixty instances.

Other instruments for estimating the corpuscular richness of blood have been designed upon the supposition that the opacity of the blood bears a fixed relation to the number of its red corpuscles. The earliest of these is the globulimeter of Mantegazza, a description of which, taken from the Berlin *Klin. Wochenschrift* for April 8, 1878, is to be found in the New York *Medical Record* for October 5th of the same year. It consists of a parallel-walled glass receptacle for the blood, a turning-disk, and a stearine taper. The blood, diluted with ninety-six times its volume of a solution of sodium carbonate, is placed in the glass vessel, the taper lighted, and "the observer looks at the flame of the taper through the openings in the disk and the blood in the cylinder, and the condition of the blood is determined from the number of blue glasses that must be used before the flame becomes invisible." Professor Mantegazza has determined that each blue glass corresponds to one hundred and twenty-five thousand red blood-corpuscles, and "has prepared a table giving the number of blood-corpuscles corresponding to each combination of glasses from one to thirty."

An objection to Mantegazza's apparatus and others of the sort, is to be found in the fact that the color of the blood does not seem to be entirely dependent upon the number of corpuscles it contains, but is greatly influenced by the state of the nervous system. Claude Bernard found that section of the cervical sympathetic caused

the blood in the jugular vein on the side of the section to become bright, and that galvanization of the superior end of the divided nerve rendered it dark again, to become once more bright on cessation of the galvanization.[4] It is impossible that these changes in color could be due to immediate changes in the number of the corpuscles. Bernard remarks: "These facts show us, therefore, that the phenomena of the coloration of the blood are not, as has been supposed, exclusively due to the capillary interchanges of the lungs and the general tissues, but that they vary under the influence of nervous action." If the blood-coloring matter were in a state of solution or suspension in the serum, an instrument, such as that of Mantegazza, might determine its amount with a very near approach to accuracy. By means of a color-test, Neubauer and Vogel have been able to determine, with sufficient accuracy for all practical purposes, the quantity of coloring-matter in a given specimen of urine. As regards the blood, however, the case is very different, its coloring-matter being intimately combined with the substance of the corpuscles, so that a change of shape in each of them, so slight as so be utterly inappreciable by any means at our command, would be sufficient to effect a decided change of color in the mass. In this connection I may also mention that, in the opinion of some observers, the color of the blood is intimately connected with the proportion of its saline constituents "a diminution of these rendering the coloring-matter dark-colored, while an increase of them has the opposite effect."[5]

Number of Blood-corpuscles in Health.—Many observations have been made to determine this point. As above stated, Vierordt gives the number for his own blood as 5,174,000 per cubic millimetre; Welcker, as somewhat under 5,000,000—about 4,950,000; Cramer, as 4,726,000; and Malassez gives a mean of observations upon eight strong, healthy males, living in Paris, of 4,310,000. Hayem and Gowers both adopt a standard of 5,000,000, but Gowers states that "in a healthy adult man the number may be a little higher, in a woman a little lower."

Keyes thinks the standard of 5,000,000 rather high. On the contrary, my own observations would lead me to regard it as about the minimum of a healthy male. A number of observations were made by Dr. C. B. Nancrede and myself to determine this point.[6] For one of us, an average of twenty-one counts gave 5,566,272; for the other, twenty-six counts give an average of 5,935,862, the difference seeming to depend upon weight and size.

My experience, in common with that of most observers, is that the number of blood-corpuscles in woman is somewhat below that of man.

The effect of age upon the number of the blood-corpuscles has been studied chiefly with reference to the periods of infancy and adult life. The blood in old age has not received so much attention. Lépine observed in the neonatus an increase in the number of corpuscles during the first twenty-four hours of life; after the second day, a decrease. Hayem finds the average number of corpuscles in the new-born child greater than in the adult, with which agree the observations of Dupérié.

At the suggestion of Dr. James C. Wilson, that an enumeration of the corpuscles in the blood of the neonatus might throw some light upon the pathology of icterus neonatorum,[7] I undertook a series of observations at the Maternity Hospital, Philadelphia, with the following results:

Case 1 was a healthy girl, weighing eight and one-fourth pounds, born after a natural labor, crying lustily when born and free from any symptoms of suspended animation. The blood was obtained by puncture of the great toe, and was venous-looking. The first count was made two and a half hours after birth: Number of red corpuscles per cubic millimetre, 6,410,000.

Second count, twenty-four hours later, child thriving: Number of red corpuscles per cubic millimetre, 5,810,000.

Third count, forty-eight hours after the last: Number of red corpuscles per cubic millimetre, 5,680,000.

Case 2, healthy male; weight, eight pounds; first count, twenty-four hours after birth. Number of red corpuscles per cubic millimetre, 5,925,000. This count corresponds closely with count number two, in Case No. 1, which was made about the same time after birth.

Second count, twenty-four hours later: Number of red corpuscles per cubic millimetre, 5,520,000

Third count, forty-eight hours later: Number of red corpuscles per cubic millimetre, 4,870,000.

Case 3, Mary C——, born 5.20 a.m., November 5th. Count made 2.30 p.m., November 6th, child weighed six and three-fourths pounds at birth, labor natural. Number of red corpuscles per cubic millimetre, 3,625,000; proportion of white cells to red, 1 to 145.

"This case" (I quote from my paper above cited) "was undoubtedly one of congenital anæmia. The child's only appearance of mal-nutrition was a shrivelled state of the integuments of the feet, and a less rosy color of the skin than normal. For a new-born child it was decidedly pale. This shrivelled state of the skin emphatically negatives the idea of a relative anæmia from excess of fluid. The blood was probably deficient in quantity (oligæmia) as well as defective in quality (oligocythæmia). There was also a decided increase in the number of the white cells. Careful inquiry proved that there had been no hæmorrhage from the cord. As possibly bearing upon the congenital imperfection of this child, I may mention the facts that the parents were themselves immature—the father being seventeen and the mother eighteen years old."

Case 4, Wm. S——, born November 6th, 5 a.m.; weight, six and a half pounds. First count, November 7th: Number of red corpuscles per cubic millimetre, 4,520,000; white cells to red, 1 to 904.

Second count, November 8th, 11 a.m.: Number of red corpuscles per cubic millimetre, 5,335,000; white cells to red, 1 to 711.

Case 5, Sela F——, female, born November 17th, 8.15 a.m.; weight seven pounds; labor rapid and natural; child healthy-looking. First count, November 19th, 10.30 a.m.: Number of red corpuscles per cubic millimetre, 5,185,000; white cells to red, 1 to 350.

Second count, November 21st, 4 p.m.: Number of red corpuscles per cubic millimetre, 5,495,000; white cells to red, 1 to 628.

The foregoing observations demonstrate that the number of the red corpuscles may either increase or diminish during the first few days of life, and that, in the new-born as in the adult, there are great individual variations.

The function of *lactation* performed by a healthy woman with abundant nutritious food does not reduce the number of the red corpuscles.

I made twelve counts of the blood of a nursing woman whose child, then fourteen months old, had been almost exclusively nursed until it was a year old, and at the time of the counts was nursed eight or nine times in the twenty-four hours. The twelve counts gave an average of 5,034,583.

Menstruation slightly reduces the number of the corpuscles, but the loss is more than made up on the day following its cessation.

Diurnal Variation in the Number of the Red Blood-corpuscles.—An average of forty-seven counts of my own blood, made at different periods of the day, showed a regular rise and fall in the number of the red corpuscles, coinciding with variations in the body temperature.*

The counts were made at four different periods of the day, as follows: Eleven, at or about 7 a.m.; thirteen, at or about 11 a.m.; thirteen, at 5 p.m.; and ten, at or about 9 p.m.; and at every count I took the body temperature by holding a thermometer in my mouth while counting.

The following are the averages of the whole series of counts:

Early morning.	Forenoon.	Afternoon.	Evening.
5,834,090.	5,502,077.	5,394,230.	5,493,500.

Averages of the temperature observations:

Early morning.	Forenoon.	Afternoon.	Evening.
98.52.	99.03.	98.88.	98.31.

* For full details see the writer's Cartwright Essay, entitled Observations with the Hæmacytometer, etc., published by F. A. Davis Att'y, Philadelphia, 1881.

From these figures it will be seen that the greatest difference between any two *successive* counts is between those of 7 and 11 A.M., and, corresponding with this, it will be noticed that, although there is a greater difference between the temperatures of 5 and 9 P.M. than between those of 7 and 11 A.M., the former are, one of them, but 0.38 above the normal,* and the other 0.19 below it; while of the two latter, the 7 A.M. temperature is about normal, and the 11 A.M. 0.53 *above* it. It is coincident with the rise above the normal that the greatest destruction of blood-corpuscles occurs.

The results of my temperature observations are decidedly at variance with the statements of E. Wagner regarding the daily fluctuations. According to that eminent authority the maximum is "usually attained at the fifth hour P.M.," although he goes on to remark that "the magnitude of this daily fluctuation of the animal heat, its highest and lowest limits, the time of maximum and of minimum, . . . and the proportionate average temperature are different, for unknown reasons, in some individuals, even if they are in absolutely the same extraneous circumstances."

I have suggested the probability that these individual differences of body-temperature are associated with corresponding differences in the diurnal variation of the number of red blood-corpuscles.

DILUTING FLUIDS.—In my first counts of blood-corpuscles I employed, for diluting the blood, the borax-urine solution of Keyes, but for more than five years I have employed a solution of sulpho-carbolate of sodium, specific gravity, 1.020. I cannot endorse the statement of Keyes that his borax-urine fluid remains free from bacteria, nor do I claim that the sulphō-carbolate solution remains free from them indefinitely. My custom is to prepare a considerable quantity of the solution, and occasionally to renew the supply in the small vial of the hæmacytometer case. In that manner I am spared the annoyance of bacteria. Their presence in the fluid may amount to more than an annoyance, for they communicate a movement to the corpuscles sufficient at times to make them cross the boundary lines of the squares, and thus to interfere with the result of the count. Keyes has invented another fluid, made by adding corrosive sublimate in definite amount to urine, which he prefers to any other. Such a fluid would certainly remain free from bacteria, since corrosive sublimate is the most powerful of all known germicides, but I have never used it on account of its property of bleaching the corpuscles. I early became convinced that in blood-counting the color of the corpuscles was of great assistance, and since Norris' claim to the discovery of a colorless corpuscle, and the admission by some of his opponents that the amount of hæmoglobin in the corpuscles is variable, this becomes still more important. "In a case of anæmia that recently came under my observation" (I quote from a previous paper of my own), "the globules, of which at the first examination there was the remarkably small number of 1,330,624 to the cubic millimetre, varied greatly in size, some of them being so small that, but for their color, their true nature might not have been readily recognized. One such case would, I think, convince any observer, that, in blood-globule counting, the preservation of the color of the globules is more important than that of their shape."

WEIGHT OF THE MOIST BLOOD-CORPUSCLES.—This is stated by the most competent observers to be about one-half that of the plasma. The obstacles in the way of determining the question are very great, owing first to the difficulty of isolating the corpuscles, which readily pass through very fine filters, and secondly, to the difficulty of removing from them the adherent plasma or serum.

The following method of Hoppe-Seyler, based upon finding the relative weight of fibrin in the liquor sanguinis and in the blood, is to be recommended in preference to any other. The following clear description of the process is taken from Professor Gamgee's "Physiological Chemistry:" "Blood is received in a cylindrical vessel which is surrounded with ice, and at the same time another portion of thirty to fifty cubic centimetres of blood is collected, and the fibrin determined in it. . . . After an interval of an hour or two, the corpuscles having had time to subside from the liquor sanguinis in the sample of blood first collected, from thirty to fifty cubic centimetres of the clear liquid are drawn off by means of a cooled pipette, and placed in a second apparatus for the extraction of fibrin, and the process carried out exactly as in the first case. The amount of fibrin being known, the operator is in possession of the data required to be known."

The calculation will be understood by quoting the following example from v. Gorup-Besanez.

1. The weight of fibrin in 1,000 grammes of blood was found to be 3.95 Gm.

2. The weight of fibrin in 1,000 grammes of liquor sanguinis was found to be 8.07 Gm.

If 8.07 Gm. of fibrin correspond to 1,000 Gm. of plasma, to how much plasma will 3.95 Gm. of fibrin correspond?

$$8.07 : 1,000 :: 3.95 : x$$
$$x = \frac{1,000 \times 3.95}{8.07} = 486.98.$$

Thus is found the weight of plasma in 1,000 parts of blood, and the weight of moist corpuscles is found, by subtraction, to amount to 1,000 − 486.98 = 513.02.

CHEMICAL COMPOSITION OF THE RED CORPUSCLES.—1. *Oxy-hæmoglobin.* The most important constituent of

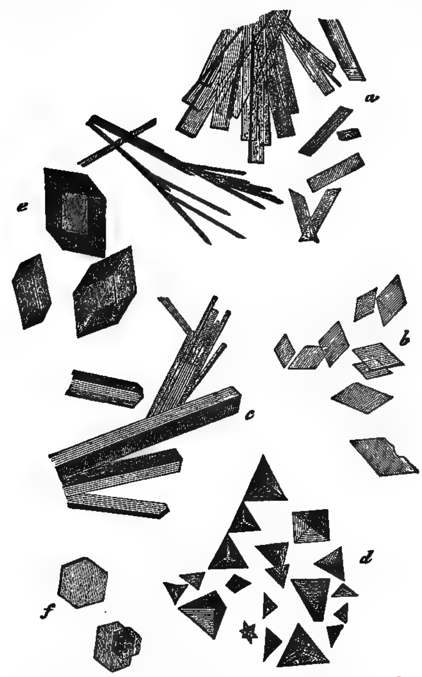

FIG. 437.—Crystals of Hæmoglobin. *a*, *b*, of man; *c*, of cat; *d*, of Guinea-pig; *e*, of hamster; *f*, of squirrel. (Ranvier.)

the red corpuscles, both in quantity and function, is the hæmoglobin, formerly called also hæmato-globulin and hæmato-crystallin. The term hæmoglobin has now entirely superseded the others. It is a crystallizable, albuminous substance, and always exists in the body loosely combined with oxygen. It is therefore called oxy-hæmoglobin, to distinguish it from the same substance deprived of its oxygen by reducing agents. To this latter the term hæmoglobin, simply, is applied.

The crystals of oxy-hæmoglobin are obtained with varying facility from the blood of different animals, most easily from the blood of the rat, Guinea-pig, and squirrel; with the greatest difficulty from that of the pig, cow, and frog. The blood of man occupies an intermediate posi-

* By the normal is here meant 98.50. The term is arbitrarily used, as all the temperatures were normal.

tion with regard to the facility with which these crystals may be obtained. From the blood of the rat they may be obtained in a few minutes, in the form of needle-shaped crystals, by mixing one drop of the blood on a glass slide with one drop of distilled water.

It may be stated in general terms that the crystals may be obtained by the action of the various agents which deprive the corpuscles of their coloring matter and render the blood lake-colored; such as alternate freezing and thawing, electricity, a temperature of 60° C. (140° F.); powdered salts, ether in substance or vapor, chloroform, and the alkaline salts of the bile. Putrefaction causes the formation of crystals of enormous size—three to five centimetres long, from dog's blood—while, on the other hand, if the blood be conducted directly from the vein or artery into a tube in which the germs of putrefaction have been destroyed by heat, the formation of microscopic crystals is prevented. It would appear as if the process of putrefaction destroyed substances which are preventive of crystallization.

The crystals of the blood of man and most of the lower animals take the form of prisms or rhombic plates of a blood-red color. They all belong, as far as known, to the rhombic system, with the exception of those of the squirrel, which belong to the hexagonal. They are all doubly-refracting and pleochromatic.

Chemical Composition of Oxy-hæmoglobin.—Crystallized oxy-hæmoglobin may be dried at a temperature of 0° C. (32° F.) without decomposition, and yields its water of crystallization at 100° C.

Hoppe-Seyler analyzed the oxy-hæmoglobin of the dog, squirrel, Guinea-pig, and goose; C. Schmidt that of the dog, and Kossel that of the horse.

The following is the mean percentage composition of the various analyses, excluding that of the horse by Kossel, which has been criticized by Hoppe-Seyler on account of its having been made by a method different from that followed in his own investigations. It gives a much higher percentage of nitrogen than any of the other analyses.

In 100 parts—

C	54.00
H	7.25
N	16.25
Fe	0.42
S	0.63
O	21.45
	100.00

It is the only proximate principle of the body that contains iron. The ash remaining after the combustion of oxy-hæmoglobin consists of pure oxide of iron, and since all the iron of the blood is contained in the oxy-hæmoglobin, it follows that the percentage amount of hæmoglobin in a given amount of blood may be determined by the amount of oxide of iron in its ash. This may be done by the following equation:

Let m be the iron in the ash of 100 parts of blood, then

$$x = \frac{100\,m}{0.43},$$

0.43 being the average percentage of iron in oxy-hæmoglobin.

Oxy-hæmoglobin is slightly acid, as shown by its reaction with litmus paper and by its separating from the blood in crystalline form at the positive pole of a battery.

Determination of the Amount of Oxy-hæmoglobin by Means of the Color Test.—That the color of the blood is dependent entirely upon its oxy-hæmoglobin was demonstrated by Hoppe-Seyler when he discovered that the absorption spectra of blood and of a solution of oxy-hæmoglobin are identical. Upon this fact is based the color test, first employed by Hoppe-Seyler. He prepared a solution of pure hæmoglobin of known strength, and then noted how much water must be added to a given amount of blood in order that equal layers of the two fluids should present the same color. He invented a glass receptacle for the two fluids, with parallel walls, one centimetre apart, which he called the Hæmatinometer. By an elaborate calculation he arrived at the amount of hæmoglobin in a given amount of blood. It is unnecessary to give any further details of this method, as at the present day it is little employed, on account of the trouble of preparing and preserving the hæmoglobin for the standard solution.

It was discovered by Rajewsky that a solution of picro carminate of ammonia could be made of precisely the same tint as a standard solution of oxy-hæmoglobin. He compared the results of the estimation of the hæmoglobin by means of this fluid with those obtained by Hoppe-Seyler's method, and found them to correspond very closely.

Malassez adopted a standard solution of picro-carminate of ammonia for use with his instrument for estimating the amount of oxy-hæmoglobin in blood. This instrument, called the *Colorimètre*, or, more frequently, the Hæmochromometer, consists (1) of a hand screen perforated with two apertures, before one of which is a movable glass prism containing the standard solution; (2) a Potain pipette which differs from the one used for blood-counting in that the walls of the dilated portion are parallel. The blood to be examined is drawn into the pipette, up to a certain mark, and then diluted with one hundred parts of water, which is drawn after the blood into the reservoir in the ordinary manner. The reservoir containing the blood mixture is now placed in front of the second opening in the screen, and the two fluids compared. By altering the thickness of the layer of the test fluid by moving the prism up or down, its color is made to correspond with that of the blood under examination. "Then the figure on the scale attached to one side of the trough is read off, and this indicates, by reference to the table annexed to the apparatus, the points to be determined."

Dr. Gowers' Globinometer. —The Globinometer (Fig. 438) of Gowers, like his Hæmacytometer, has been planned

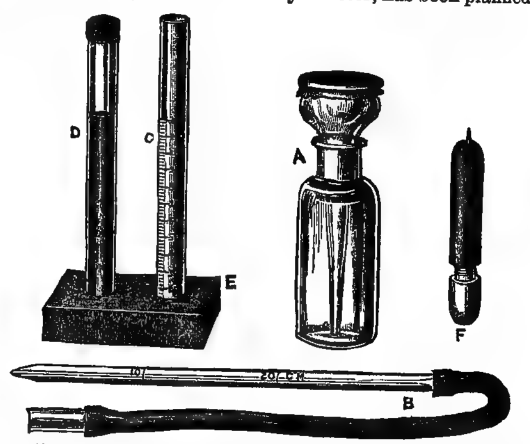

FIG. 438.—Gowers' Globinometer. E, wooden stand supporting tubes C and D; D, tube containing glycerine jelly tinted with picro-carmine; C, graduated tube in which the blood is diluted with water; B, capillary pipette, marked so as to allow of 20 c.mm. of blood being measured; F, needle for puncturing the finger; A, bottle of distilled water. (Gamgee.)

with special reference to an easy calculation of the percentage amount of oxy-hæmoglobin in a given amount of blood, and on this account it deserves the preference over all other instruments of the sort.

The color of a dilution of normal blood one hundred times (20 c.mm. of blood to 2 c.ctm. of water) is taken as the standard. "The quantity of hæmoglobin is indicated by the amount of distilled water needed to obtain the tint with the same volume of blood under examination as was taken of the standard. On account of the instability of a standard solution of blood, tinted glycerine jelly is employed instead. This is perfectly stable, and by means of carmine and picro-carmine the exact tint of diluted blood can be obtained."

The apparatus consists of two glass tubes, one of which contains a standard of the tint of 20 c.mm. of blood in 2 c.ctm. of water (1 in 100). The second tube is granulated, 100 degrees = 2 c.ctm.

Twenty cubic millimetres are measured in a capillary pipette, and quickly blown into the graduated tube in which has been previously placed a few drops of distilled water to prevent coagulation. Distilled water is then added, drop by drop, until the tint is the same as that of the standard. The number of degrees to which the level of the fluid has reached, indicates the percentage amount of oxy-hæmoglobin. For instance, if 20 c.mm. of blood gives the standard tint at fifty degrees of dilution, it contains only fifty per cent. of the normal amount of oxy-hæmoglobin.

"By ascertaining with the hæmacytometer the corpuscular richness of the blood, we are able to compare the relation between the number of corpuscles and the amount of hæmoglobin. A fraction, of which the numerator is the percentage of hæmoglobin, and the denominator the percentage of corpuscles, gives at once the average value per corpuscle." Thus, if a specimen of blood contained thirty per cent. of hæmoglobin and sixty per cent of corpuscles, the average value of each corpuscle would be $\frac{30}{60}$, or $\frac{1}{2}$ the normal.

"The instrument is only expected to yield approximate results, accurate within two or three per cent. It has, however, been found of much utility in clinical observations."

Spectrum of Oxy-hæmoglobin.—If a solution of oxy-hæmoglobin, of which the strength neither exceeds nor falls below certain limits, be placed in a glass vessel with parallel walls and brought before the slit of the spectroscope, two absorption bands make their appearance between the Fraunhofer lines D and E (Fig. 439). Of the two bands, the one nearer to the line D is sharper in outline and narrower than the one adjoining the line E. Besides these two bands there is also an obscuration of the red and violet ends of the spectrum, of which the latter is much the more extensive.

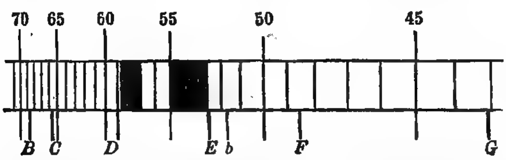

FIG. 439.—Spectrum of Oxy-hæmoglobin. The numbers attached to the scale indicate wave-lengths expressed in hundred-thousandths of a millimetre. The letters indicate the lines of Fraunhofer. (Rollett, in "Hermann's Handbuch der Physiologie.")

These spectroscopic appearances are produced by the blood of all vertebrate animals, and have been shown to proceed from the red corpuscles, except in the case of the Amphioxus, in which animal the blood-coloring matter is found in the plasma.

The spectrum of oxy-hæmoglobin may be obtained by holding a rabbit's ear between the light and the slit of the spectroscope, from the web of the frog's foot, and by reflecting light from the surface of the skin.

Vierordt's method of performing the latter experiment consists in holding two closely approximated fingers before the slit of the spectroscope and allowing direct sunlight to pass between them.

In the spectrum analysis of blood certain precautions are necessary. Thus, if the solution of oxy-hæmoglobin is too strong, all light is cut off. By diluting such a solution, a band of red and orange first appears; and on still farther dilution a narrow band of green is visible, separated from the band of red and orange by a broad absorption band. This, on diluting still more, divides into the two characteristic absorption bands of oxy-hæmoglobin. By continuing this process of dilution the two bands become narrower until the one nearer the E line disappears. Finally the other one disappears also, leaving the continuous spectrum of light.

The two absorption bands are seen most distinctly when a layer, 1 ctm. thick, containing 1 part of oxy-hæmoglobin in 1,000, is examined.

Methods of determining the percentage of oxy-hæmoglobin from the spectroscopic appearances of different strengths of its solution were first employed by Preyer, and, after him, by Vierordt, Höfner, and others. These methods are not so accurate as the color-tests of Hoppe-Seyler, Malassez, and Gowers, above described.

SPECTRUM OF HÆMOGLOBIN.—The oxygen contained in oxy-hæmoglobin exists in such loose combination that it is readily displaced by indifferent gases, such as N and H, and still more readily by substances that possess an affinity for O. Among the latter are ammonium sulphide, iron filings, iron reduced by hydrogen, and Stokes' fluid, which is an ammoniacal solution of ferrous sulphate slightly acidulated with tartaric acid. This property of oxy-hæmoglobin, of readily yielding its oxygen, was first discovered by Professor Stokes, who also observed that the reduction coincided with changes in its color and in its spectrum. The color changes from scarlet to purple, and the spectrum presents one absorption band between the Fraunhofer lines D and E, where before two were visible. This band has its darkest portion where the green interspace existed between the two bands (Fig. 440).

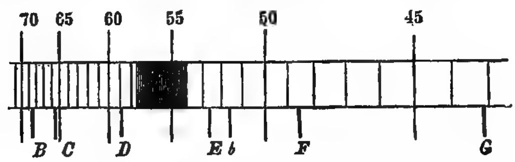

FIG. 440.—Spectrum of Reduced Hæmoglobin. (Rollett.)

Reduced hæmoglobin is dichrotic, thick layers of its solution appearing of a dark cherry-red, and thin layers green. The same dichrotism is observed in venous blood.

Action of Carbonic Oxide, CO.—When animals are poisoned with this gas, or when it is passed through blood or a solution of oxy-hæmoglobin, it displaces the oxygen of the blood-coloring matter and takes its place molecule for molecule. The combination thus formed is remarkable for its stability, although, contrary to what was formerly supposed, it can be reduced by an indifferent gas, or in a vacuum. Its crystals are isomorphous with those of oxy-hæmoglobin, but have a slight bluish tinge. Its spectrum is almost identical with that of O-hæmoglobin, but the two absorption-bands are moved very slightly nearer the violet end.

NITRIC OXIDE, NO, forms a still more stable compound with hæmoglobin. It will displace carbonic oxide. Its crystals are isomorphous with the oxygen and CO compounds, and its spectrum is almost identical with theirs.

METHÆMOGLOBIN.—A product of the decomposition of oxy-hæmoglobin produced by exposure of blood to air and by the addition of acids, nitrites, permanganate of potassium, and some other substances. Its spectrum differs from that of oxy-hæmoglobin by the addition of a new band in the red.

Authorities differ as to the chemical composition of this substance. Some regard it as a higher degree of oxidation (a hyperoxide) of oxy-hæmoglobin, while Hoppe-Seyler considers that it contains less oxygen than oxy-hæmoglobin, but more than reduced hæmoglobin. Others regard it as a mixture of hæmatin with a soluble albumen.

The spectrum of methæmoglobin has been seen by MacMunn "in the urine of acute desquamative nephritis, in that of post-scarlatinal nephritis, and in the blackish-brown fluid vomited in some cases of hæmatemesis."

Hæmatin.—This substance is obtained by treating blood with acetic acid, or, still more readily, by dissolving hæmin crystals (hydrochlorate of hæmatin) in a dilute solution of potassium hydrate and adding hydrochloric acid. Hæmatin is then thrown down in a flocculent, brown

precipitate. It is amorphous, and insoluble in water, alcohol, ether, and dilute acids, but dissolves in solutions of the caustic alkalies, and is slightly soluble in alcohol rendered acid or alkaline.

In alkaline solution its spectrum contains one broad absorption band covering, D Fraunhofer. In acid solution it gives four absorption bands.

Hæmin, Hydrochlorate of Hæmatin.—This substance is important from a medico-legal point of view, on account of the readiness with which it may be obtained from minute quantities of blood.

A drop of blood is allowed to dry upon a slide; a small quantity is then scraped off and placed upon another slide; to this powdered blood is then added a small quantity of sodium chloride; a few drops of glacial acetic acid are next added, a cover-glass applied, and the slide held over the flame of a spirit-lamp until air-bubbles appear. Hæmin crystals will be found. They are in the form of rhombic plates (Fig. 441), varying in color from a bright yellow to a dark brownish-black. They may be obtained from the oldest blood stains by cutting out the stained tissue and boiling it in glacial acetic acid containing a little sodium chloride. The fluid is then evaporated and the crystals are deposited. After the spectroscope this is the best test for the presence of blood.

FIG. 441.—(Ranvier.) Hæmin Crystals.

Hæmochromogen.—This substance is formed when reduced hæmoglobin is decomposed in the absence of oxygen. In alkaline solution its spectrum is identical with that of reduced hæmatin. When brought in contact with oxygen it is instantly converted into hæmatin.

Hæmatoporphyrin is iron-free hæmatin.

Hæmatoidin (Fig. 442).—A product of metamorphosis of oxy-hæmoglobin found in old blood extravasations and in the corpus luteum, usually in the form of rhomboidal prisms of an orange or ruby-red color, also in amorphous granular and globular masses. By most physiological chemists it is considered to be identical with bilirubin.

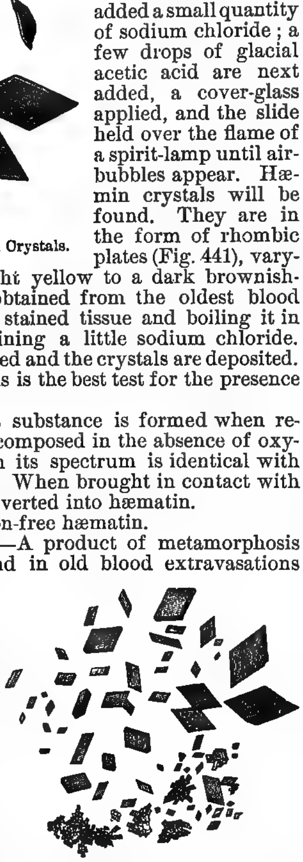

FIG. 442.—(Frey.) Crystals of Hæmatoidin. Ordinary form.

OTHER CONSTITUENTS OF THE RED CORPUSCLES. — *Protagon, Lecithin.* The existence of protagon in the red corpuscles was at one time generally acknowledged. The observations of Hoppe-Seyler and Jüdell have, however, shown that the fatty phosphorized constituent of the red corpuscles contains a larger percentage of phosphorus than does protagon. They consider it to be identical with lecithin, a substance first found in the eggs of the carp by Gobley, and subsequently in the brain by Diaconow. *Cholesterin* is invariably found in the red-corpuscles, and may be separated from them by ether.

MINERAL CONSTITUENTS.—It is impossible to determine these with accuracy, because the corpuscles cannot be completely isolated. It is known, however, that they are much richer in potassium salts than the serum, and that the serum contains more chlorine than the corpuscles. As to the sulphates and phosphates it cannot be determined whether these exist as such in the corpuscles, or are the result of oxidation of organic ingredients. The phosphoric acid in the ash of the corpuscles is derived from the oxidation of lecithin. The iron is derived entirely from hæmoglobin.

THE WHITE CORPUSCLES.

These bodies, known also as leucocytes and colorless corpuscles, exist in the blood of man in the proportion of one white to about five hundred of the red corpuscles. These figures are merely approximative. They are diminished by fasting, and increased by eating. Their enumeration is made by the same instruments employed for counting the red corpuscles. The proportion of one white to five hundred red would give the former a number of ten thousand per cubic millimetre, supposing the red corpuscles to be five million per cubic millimetre.

They are spherical granular masses of protoplasm, destitute of a membrane, containing one or more nuclei and sometimes a number of fat granules. Their most remarkable property is the power they possess of spontaneous movement, which brings them into remarkable analogy with the unicellular rhizopod known as the amœba. The movement has hence been called amœboid.

They have a diameter of about ten μ ($\frac{1}{2500}$ in.). Max Schultze has described two varieties of smaller colorless corpuscles; one with a diameter less than that of the red corpuscles, and containing one or two nuclei; the other of the same diameter as the colored corpuscles, and also nucleated.

The white corpuscles are of lower specific gravity than the red, as is shown by their accumulation in a layer between the red corpuscles and the plasma in blood in which coagulation has been delayed by a temperature of 0° C.

Their adhesiveness is so great that, in a blood preparation, the red corpuscles can be washed away by a stream of water, leaving the white corpuscles attached to the object- and cover-glasses.

By means of their amœboid movement the white corpuscles have the power of penetrating animal membranes. Thus they have been observed to pass through the shell membrane of an egg that has been placed in contact with a suppurating surface. This phenomenon is observed in the living body by exposing a transparent membrane, such as the mesentery, to the air. Inflammation is set up, and the white corpuscles pass gradually through the walls of the capillaries and veins. This migration, known as diapedesis, is undoubtedly the chief factor of the inflammatory process. It was first observed by W. Addison in 1842; then by Waller in 1846, but was forgotten until Cohnheim discovered it anew in 1867. The latter, by his demonstrations of its paramount importance in the inflammatory process, established a new era in pathological science.

CHEMICAL COMPOSITION OF THE WHITE CORPUSCLES.—Owing to the comparatively small quantity of these elements in the blood, inquiries as to their chemical composition are attended with much greater difficulty than is the case with regard to the red corpuscles. The analyses of the corpuscles, as they exist in healthy and leukæmic blood, have been supplemented by analyses of the leucocytes as they exist in pus.

The mass of the white corpuscles is undoubtedly a proteid, and inasmuch as it is contractile, it is regarded by some as probably identical with the myosin derived from muscle.

Some of the granules contained in the corpuscles are soluble in ether and alcohol, and are, therefore, considered to be fat-drops, either taken up into the substance of the corpuscle from without, or a product of protoplasmic metamorphosis.

They also contain *cholesterin* and a fatty phosphorus-containing body, which is by some regarded as *protagon*, by others as *lecithin*.

Another phosphorized constituent is found in the nucleus, and is called *nuclein*. It was first observed by Miescher in the nucleus of pus-corpuscles, afterward by Lauder Brunton and Plosz in the nuclei of red nucleated corpuscles (those of birds and snakes). This substance closely resembles mucin, and possesses the peculiarity of not being acted upon by gastric juice. This property affords a ready means of isolating it. *Glycogen* is also a constituent of the white corpuscles, and may be demonstrated by the mahogany-red color induced by the action of a solution of iodine in potassium iodide and water.

THE PLASMA AND SERUM OF THE BLOOD.

The plasma, or liquor sanguinis, is the serum plus the body or bodies concerned in the production of fibrin. It may be obtained comparatively pure from blood—preferably that of the horse, on account of the slowness with which it coagulates—that has been kept at a temperature of 0° C. until the corpuscles subside; or, mingled with water and saline substances, by adding to the blood certain salts that prevent coagulation, the most important of which are sodium and magnesium sulphate.

Its specific gravity scarcely differs from that of serum, being from 1.027 to 1.028.

Its alkaline reaction is not so marked as is that of the serum separated from it.

On raising the temperature of plasma above 0° C., it coagulates into a gelatinous mass from which, as it contracts, exude drops of serum until the coagulum, which is comparatively small and colorless owing to the absence of blood-corpuscles from its meshes, is surrounded on all sides by serum.

SERUM may be obtained from plasma as above mentioned, or more commonly from blood. The process of obtaining pure serum from blood is greatly facilitated by the use of a centrifugal machine. This consists of a turn-table to which is attached the tube containing the blood. After a rapid rotation of half an hour the clot is found retracted to the peripheral end of the tube, while from the portion directed toward the centre of the turn-table serum entirely free from corpuscles may be obtained (Fig. 443).

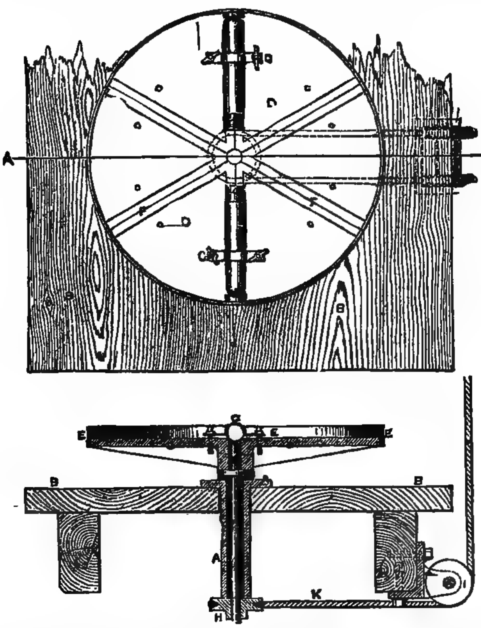

FIG. 443.—(Gamgee.) Centrifugal Machine used in the Laboratory of Owens College. A, an iron socket secured to top of table B; C, a steel spindle carrying the turn-table D and turning freely in A; E, a flange round turn-table D; F F, shallow grooves on face of D in which the test-tubes are fixed by clamps G G; H, a pulley fixed to end of spindle C, and turned by the cord K; I I, two guide-pulleys for cord K.

The serum obtained from the blood of man while fasting is a transparent, pale yellow fluid. After a full meal it is opaque and milky, owing to suspended particles of fat. As above stated, it is more alkaline than plasma, and of about the same specific gravity, 1.028.

In 1,000 grammes of blood there are from 4.40 to 52.5 grammes of serum.

ALBUMINOUS BODIES OF THE SERUM AND PLASMA.—The most important and abundant of these is

Serum-albumin.—This body, although presenting most of the reactions of egg-albumin, is not identical with it. Serum-albumin rotates the plane of polarized light, having a wave-length corresponding to D, Fraunhofer, 56° to the left, while egg-albumin rotates it but 35.5°.

Precipitates of serum-albumin by nitric and hydrochloric acids are readily redissolved, whereas precipitates of egg-albumin are redissolved with great difficulty. Finally, egg-albumin injected into the veins appears unchanged in the urine, whereas no albuminuria follows the similar injection of serum-albumin.

For a long time serum-albumin was considered to be the only albuminous constituent of serum. It is now known that serum-globulin or paraglobulin (the fibrinoplastic substance of Schmidt) exists in the blood of man in nearly equal amount, and in even greater amount in the blood of the horse and ox.

To obtain serum-albumin from serum its serum-globulin must first be separated. This may be accomplished by diluting serum with ten to fifteen times its volume of ice-cold water, and passing through it a stream of CO_2, or, instead of the latter, by the careful addition of acetic acid. The serum-globulin is precipitated, and the serum-albumin in solution may be removed by filtration. It is then neutralized with sodium carbonate, and concentrated by evaporation at a temperature not exceeding 40° C. (104° F.), until its specific gravity is about that of undiluted serum Its salts are then removed by dialysis, after which it is evaporated at a temperature not above 40° C.

Serum-globulin is most completely removed from serum by the addition of magnesium sulphate to the point of saturation. According to Hammarsten, this salt precipitates every trace of serum-globulin without exerting any action upon serum-albumin.

The process of dialysis has also been employed in order to obtain serum-albumin. If serum be placed in a dialyser, the salts pass from it by diffusion, and the serum-globulin is precipitated from the serum-albumin. By no process thus far employed, however, can serum-albumin be obtained absolutely free from mineral constituents.

Serum-albumin, obtained by any of the above methods, is a transparent, brittle, yellow substance, soluble in distilled water, from which it may be precipitated by the mineral acids, especially nitric acid, by tannic and metaphosphoric acids, and by most of the metallic salts. It also separates in the form of a flocculent precipitate when exposed to a temperature of 72° to 75° C. (161.6° to 167° F.).

It has been given as a distinguishing mark between serum-albumin and egg-albumin that ether precipitates the latter and not the former. This statement requires some modification. The action of ether depends upon the alkalinity of the albumin solution. Egg-albumin naturally is less alkaline than serum-albumin, and it is found that when the salts are removed by dialysis from serum-albumin, the latter is also precipitated by ether.

Serum-globulin (*Paraglobulin—Fibrinoplastic Substance of Schmidt*).—The first two of the above synonyms indicate the close resemblance of this body to a proteid found in the crystalline lens, to which was given the name of globulin; the last, its supposed co-operation in the formation of fibrin. The methods of separating serum-globulin from serum have been given under the head of serum-albumin.

It is insoluble in pure water, but soluble in water holding CO_2 or O in solution, soluble in dilute solutions of sodium chloride, in weak solutions of the alkalies, and in weak solutions of alkaline salts. This applies to the fresh precipitate. After standing under water for some time, it loses its solubility in salts. In dilute solution of sodium chloride it coagulates at from 68° to 79° C. (154.4° to 174.2° F.). From very weak alkaline solutions it is precipitated by adding a minute quantity of sodium chloride; on further addition of the chloride the precipitate is redissolved. In very weak alkaline solution it is not coagulated by heat.

Serum-globulin arises, at least in part, from the destruction of the white blood-corpuscles.

Plasma, from which the white corpuscles have been separated by filtration, is found to be poorer in serum-

globulin than plasma that has not been filtered, and, on the other hand, the white corpuscles collected on the filter treated with a weak solution of alkali, yield a large percentage of serum-globulin.

Solutions of serum-globulin are not coagulated on the addition of fibrin-ferment.

FIBRIN.—Fibrin is obtained from blood by stirring it with a glass rod, to which it adheres in stringy masses. It is then washed from adhering corpuscles by prolonged immersion in running water, when it appears in the form of white threads and flakes possessing considerable elasticity. It may be observed under the microscope in the form of a delicate reticulum by allowing a drop of blood to coagulate upon a slide, then washing it free from red corpuscles by a gentle stream of water, and placing upon the colorless film a drop of a strong solution of magenta. By this process the white corpuscles are not removed, and from them radiate the delicate filaments of fibrin. These filaments are so delicate and transparent that, but for the staining, they would be made out with difficulty.

Fibrin is insoluble in pure water, but "soluble in a six per cent. solution of potassium nitrate, if digested with it for some time at a temperature of 30° or 40° C. (86° to 104° F.). It is similarly soluble in solutions of sodium chloride, and in a ten per cent. solution of magnesium sulphate. The solutions of fibrin in the neutral salts are coagulated by heating to 60° or 65° C. (140° to 149° F.), by the addition of acids and of alcohol, and by the addition of powdered magnesium sulphate."

On the addition of acetic acid and dilute mineral acids (5 per 1,000 HCl), it swells up into a transparent jelly-like mass which is insoluble. In more dilute solution of HCl (1 per 1,000), it dissolves after digestion for a few hours at a temperature of 40° C. (104° F.). By this process it is converted into acid albumin or syntonin. In the fresh, moist state, it decomposes solutions of hydric peroxide, H_2O_2 with the liberation of O.

Fibrin has the following composition · C 52.6: H, 7.0; N, 17.4; S, 1.2; O, 21.8.

FIBRINOGEN.—Fibrinogen is a constituent of the plasma, but is absent from serum. It is also found in the liquids of serous cavities, such as the pericardium, peritoneum, and pleura; also in the fluid of hydrocele. The plasma is distinguished from the other fluids mentioned, by being spontaneously coagulable. This is due to the fact that, besides fibrinogen, it also contains serum-globulin; whereas, of the others, serum contains serum-globulin but no fibrinogen, and the remainder contain fibrinogen but no serum-globulin.

Fibrinogen is soluble in weak solutions (five to eight per cent.) of sodium chloride, but precipitated by solutions containing twelve to sixteen per cent. of salt; whereas serum-globulin is not precipitated by sodium chloride, unless its solution is of a strength of more than twenty per cent. These properties afford a means of separating the two substances.

Hammarsten's method of obtaining fibrinogen is as follows:

Fresh blood is mixed with one-third its volume of a saturated solution of magnesium sulphate. It is then filtered, or, better still, submitted to the action of a centrifugal machine, in order to free it from corpuscles. To the salted plasma is now added an equal volume of a saturated solution of sodium chloride, which causes an abundant flaky precipitate. This is separated by filtration, redissolved in a six to eight per cent. solution of NaCl, and again precipitated by adding an equal volume of a saturated solution of NaCl. By repeating this process several times, fibrinogen may be obtained absolutely free from serum-albumin and serum-globulin, but containing from 1 to 1.5 per cent. NaCl.

Solutions of fibrinogen in NaCl coagulate at a temperature of 52° to 55° C. (125.6° to 131° F.). In weak alkaline solution it coagulates at 56° to 58° C. (132.8° to 136.4° F.).

Frédérique has demonstrated that fibrinogen exists as such in the blood by confining blood with ligatures in a portion of the jugular vein, and heating it to 56° C. (132.8° F.). A proteid substance (fibrinogen) separates, and the blood is no longer coagulable. The amount of fibrinogen that separates from the plasma of horse's blood, at a temperature of 56° C., is given by Frédérique as 0.4299 per cent.

The Formation of Fibrin.—In 1831, Dr. Andrew Buchanan, of Glasgow, discovered that certain serous fluids of the healthy body—those of the pericardium, pleura, and peritoneum—also certain transudates, the products of disease, such as the fluids of hydrocele and ascites, all of which are not spontaneously coagulable, will coagulate on the addition of blood-serum, or "washed blood-clot" (*i.e.*, a clot deprived of its red corpuscles by washing), or even of pieces of muscle, nerve, or connective-tissue. Of these substances he found that washed blood-clot was most efficacious in inducing coagulation, and he states that if dried and pulverized, or placed in alcohol, it may be kept for many months without losing its coagulating power.

Buchanan concluded that this property of washed blood-clot, which consists of fibrin and entangled white corpuscles, is inherent in the latter bodies. This is demonstrated by the fact that the buffy coat of the blood of the horse, which is very rich in white corpuscles, has a far greater coagulating power than equal portions taken from the lower layers of the coagulum. Buchanan compared this action of washed blood-clot and of the other substances mentioned, in inducing coagulation in liquids that do not coagulate spontaneously, to the action of rennet upon milk.

These most interesting observations of Buchanan were entirely lost sight of, until the facts were rediscovered independently by Professor A. Schmidt, of Dorpat, in 1861.

Schmidt endeavored to isolate from serum the substance to which is due its coagulating power, and believed that it was identical with the serum-globulin that he obtained from diluted serum by passing through it CO_2. He also separated fibrinogen from transudates, and demonstrated that mixing the two bodies in weakly alkaline solution results in the production of fibrin. Hence he concluded that fibrin was a product of the union of these two proteids, and that when a liquid containing fibrinogen did not coagulate spontaneously, it was due to the absence of fibrinoplastin (serum-globulin). He ascertained later that both bodies are present in the fluid of hydrocele, which is not spontaneously coagulable, and that it may be made to coagulate by adding to it blood or blood-serum. It thus appeared evident that a third factor was necessary to coagulation, and by further research Schmidt separated from the serum a soluble substance which he designates as fibrin-ferment.

Fibrin-ferment is obtained by diluting serum with ten to twenty times its volume of alcohol, and allowing it to stand in a stoppered bottle for several weeks (preferably months). The effect of this is to coagulate the proteid matters of the serum. The coagulum is dried, powdered, treated with distilled water, and filtered. The filtrate contains the so-called fibrin-ferment in solution. Such a solution added to a liquid containing fibrinogen and serum-globulin, which does not coagulate spontaneously, such as the fluid of hydrocele, will often rapidly give rise to a coagulum.

Schmidt ascribes the origin of the fibrin-ferment to a destruction of the white corpuscles, which, according to him, takes place with great rapidity after blood is withdrawn from the vessels. He adduces, in support of his view as to the origin of the ferment, the fact that, in cooled plasma from which the white corpuscles have been removed by filtration, coagulation is retarded. That it is not entirely prevented he ascribes to the supposition that an ice-cold temperature will not altogether prevent the decomposition of the white corpuscles, and the consequent development of ferment. Another observation of Schmidt's, tending to prove that the coagulation of the blood is dependent upon the presence of the white corpuscles is that, in the blood of the horse in which the corpuscles have had time to settle by the maintenance of a temperature of 0° C., coagulation is most complete in that portion in which the white corpuscles are most abundant. By counting the leucocytes in the plasma of horse's blood, and afterward in the serum of the same,

Schmidt has demonstrated that there is a disappearance of these bodies during the act of coagulation, and has determined its amount. He found that the plasma contained 14,909 leucocytes per cubic millimetre, the maximum being 17,980, the minimum 12,320. These figures are based on eleven enumerations. In nine instances he counted the leucocytes in the serum, and found an average of 4,222, the maximum being 5,080, the minimum 2,000 per cubic millimetre; 77.7 per cent. of leucocytes had disappeared in the coagulum.

Schmidt also counted the red corpuscles in blood before and after its defibrination. The average of the counts of red corpuscles in living blood was 5,317,000. In defibrinated blood it was 5,156,000, a difference of only thirty per cent. This disappearance of the leucocytes is not, he argues, a mechanical entanglement in the meshes of the fibrin, for, were this the case, there would be no such difference in the percentage of disappearance between the red and the white corpuscles. Besides, on examining a coagulum under the microscope, the red corpuscles are seen entangled in the meshes of the fibrin, while of the white not a trace remains but a few greatly altered cells; the vast majority of them have disappeared in the formation of the clot.

Schmidt's theory of coagulation is, that it depends upon the union of two bodies, fibrinogen and fibrinoplastin (serum-globulin), under the influence of a ferment, and he considers that both the ferment and the fibrinoplastin are derived from the white blood-corpuscles.

Later, Hammarsten has contended that serum-globulin is not a necessary factor in the act of coagulation, and that when coagulation follows its addition to a solution of fibrinogen, it is because of its having contained the ferment. He has prepared fibrinogen entirely free from serum-globulin, and produced coagulation by the addition of fibrin-ferment alone. He admits that the presence of serum-globulin increases the yield of fibrin, and will sometimes induce coagulation in a transudation when the addition of the ferment has failed to do so; but he has shown that other substances, such as $CaCl_2$ and casein, will have the same effect, and, therefore, he considers serum-globulin to be a non-essential factor in the act. This theory is almost identical with that of Dr. Andrew Buchanan.

Other views of the cause of the coagulation of the blood are those which refer it to changes in some of its morphological elements.

A valuable contribution of this nature has been made by L. C. Wooldridge, B. Sc., London, in a communication to the Royal Society ("Proc. Roy. Soc.," No. 214, 1881). This observer found that after completely isolating the cells of the lymphatic glands by a process given in his paper, and adding to them simple chemical reagents, such as a ten per cent. solution of common salt, the cells were changed into a substance having the macroscopic appearance and chemical behavior of fibrin, and, under the microscope, showed a distinctly fibrous ground-substance, in which the nuclei of the cells were embedded, the cells, as such, having entirely disappeared.

The following quotations from Wooldridge's paper will give an idea of the nature of his researches:

"The two components" (of fibrin) "which arise from the white blood-corpuscles are, according to Schmidt, paraglobulin and fibrin-ferment. The recent researches of Hammarsten have made it very probable that paraglobulin is not directly concerned in the production of fibrin. If this is true, and if the views of Schmidt concerning the participation of the white corpuscles be also correct, the latter must necessarily play only a very subordinate part, that is, they must be mere ferment producers." . . . "The generally received view as to the course of events in the normal coagulation of the blood is as follows: Very soon after leaving the body the white corpuscles die; as a consequence of this they break up, and thereby give rise to the ferment and paraglobulin. The fibrinogen is pre-existent in the plasma. According to this view, then, the essential element in coagulation is the death of the white blood-corpuscles. The results of my experiments are totally opposed to this view."

Wooldridge injected a large quantity of dead lymph-cells, obtained from the lymphatic gland, into the blood of a living dog, both in its normal state and after being peptonized,* without any marked influence upon the functions of the animal. No sign whatever of emboli was detected by post-mortem examination. (2.) "A dog was peptonized; five minutes later a small quantity of blood was removed and divided into two portions; to the one lymph-cells were added. It coagulated immediately, exactly like normal coagulation. The other portion remained uncoagulated for hours." From these and other experiments, Wooldridge concludes that coagulation is caused by a change in the plasma, and has nothing to do with the vital properties of the cells, and that the conversion of the white cells into fibrin is quite independent of the presence of any fibrinogen substance. "Fibrinogen is present in living plasma, yet the dead cells produce no coagulation. Fibrinogen was absent from the peptone plasma, which still gave practically unlimited quantities of fibrin with lymph-cells." "There are," says he, "two essential processes in the coagulation of the blood, one of which has been hitherto entirely wrongly appreciated or overlooked. This latter process is that the dead plasma converts the white corpuscles directly into fibrin. At the same time, however, that this occurs, a substance is liberated from the cells which converts the fibrinogen also into fibrin. This is the other process. The substance which is liberated from the cells is fibrin ferment."

Dr. Richard Norris, of Birmingham, ascribes the formation of fibrin to changes in bodies intermediate between the lymph-cells and the red blood-corpuscles, many of which have the same refractive index as the serum, and are, therefore, invisible when suspended in that fluid. When the serum is withdrawn from these bodies by methods fully described by Norris in his work on the "Physiology and Pathology of the Blood," they readily come into view. Norris' work is illustrated by photographs which show the transformation of these bodies into fibrin.

On the other hand, Hayem and Bizzozero deny the existence of the colorless corpuscle of Norris, which they regard as a red corpuscle deprived of its hæmoglobin by artificial methods, and attribute the formation of fibrin to a transformation of elements of the blood to which they give the names, respectively, of

Hæmatoblasts and Blutplättchen.—These bodies have been observed by Donné and described by him under the title *globulins*, although so imperfectly that the term has never carried with it an exact signification; by Andral, Zimmermann, Max Schultze, Riess, Beale, Osler, Vulpian, Ranvier, and, perhaps, others. They form the component parts of certain granular particles commonly observed in blood withdrawn from the vessels by microscopists, although first accurately described by Max Schultze, and, therefore, known as Schultze's granule masses. They are more numerous in the young than in the adult animal, and may be readily seen in the blood-vessels of the young rat, as first pointed out by Osler ("Proc. Roy. Soc.," June 18, 1874), by snipping out a piece of the subcutaneous tissue and examining it in salt solution.

Of the writers above mentioned, Ranvier, Hayem, and Bizzozero have assigned to the bodies in question, a prominent part in the act of coagulation. At a meeting of the Société de Biologie, held February 1, 1873, Ranvier described them in detail and concluded, from a study of their histo-chemical reactions, that they were particles of fibrin which operate as centres of coagulation, just as a crystal of sodium sulphate placed in a solution of the same salt will act as a centre of crystalline deposit. He acknowledged that he was unable to determine whether the granulations, as he called them, exist as such in the circulating blood, but considered it highly probable that

* "The most convenient way of obtaining plasma from dog's blood is to inject a solution of peptone into the blood of the living animal. If the animal be bled five or ten minutes after the injection of the peptone, the blood does not coagulate. (This fact was discovered by Dr. Adolf Schmidt, Mulheim.) By means of the centrifugal machine the blood-corpuscles can be separated from the plasma" (Wooldridge, *loc. cit.*).

they do, since they are seen immediately after blood is withdrawn from the body (*Gazette Méd.*, 1873, p. 94). At the same meeting M. Vulpian remarked, that he had already called the attention of the society to these bodies which he had constantly observed in the blood of patients at the Pitié Hospital, especially in cases of typhoid fever and erysipelas. In such patients they are far more numerous than the white cells, and in certain cases of erysipelas their number approached that of the red corpuscles. Similar observations as to the abundance of these elements in cachectic states of the system had been previously made by Riess. In consequence of a movement of these bodies, which Vulpian believed to be of an active character, he called them *grains sarcodiques.*

By far the greater portion of our knowledge concerning the blood-plates has been furnished by Hayem and Bizzozero; by the former in several articles in the *Archives de Physiologie*, for 1878 and 1879, and by the latter in an elaborate article in *Virchow's Archiv*, Bd. 90. They can be readily seen in the circulating blood of the Guinea-pig by carefully stretching a portion of the mesentery over a ring of cork fastened to a glass slide, the animal having been previously rendered motionless by chloral or chloroform, or they may be observed in the blood of man by placing a drop of a three-fourths per cent. salt solution tinted with methyl violet upon the finger, puncturing with a needle through the fluid, and pressing the blood directly into it.

The following fluid is also recommended by Hayem for the study of these very perishable bodies. It has the

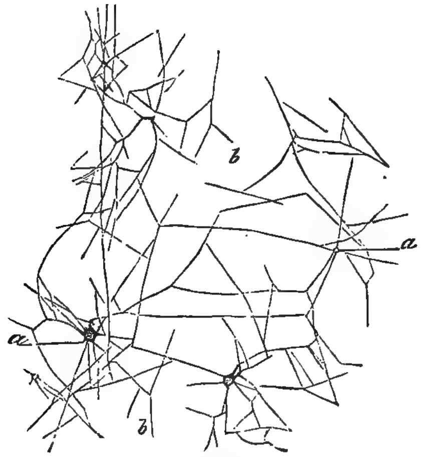

FIG. 444.—Fibrinous Reticulum of Human Blood. (Ranvier.) *a*, "Fibrinous granulation" (blood-plate), forming the centre of a reticular system; *b*, reticular fibres. (500 diameters.)

property of fixing their form and preserving them unaltered for a considerable time. One drop of blood should be mingled with from twenty to one hundred of the fluid: Distilled water, 100; sodium chloride, 1; sodium sulphate, 5; mercuric bichloride, 0.50.

The blood-plates are not products of the degeneration of white corpuscles, as some have supposed, for their form is constant, not that of irregular particles of disintegration. Their chemical constitution is also different, for while the white corpuscles retain their form and contractility for a considerable time, the blood-plates begin to alter as soon as they are withdrawn from the vessels, and in a few moments are unrecognizable. They appear to stand in a constant relation to the red corpuscles, so far as their size is concerned. Thus they are larger in man and in the dog than in the lamb and Guinea-pig, the red corpuscles being larger in the two first-named animals, and in animals with nucleated red corpuscles the blood-plates are also nucleated.

Scarcely are the blood-plates withdrawn from the vessels than they begin to change their appearance by a division into two portions, a peripheral, grayish, and finely granular, and a central, more strongly refractive, vitreous-like portion. The peripheral substance is remarkable for its viscosity, through which property it adheres to neighboring plates, sometimes in star-shaped or chapelet-like forms, from the borders of which, as well as from individual plates, proceed a great number of exceedingly fine prolongations, which cross each other in various directions and form an irregular network of which the starting-point is undoubtedly the blood-plates (Fig. 444). These appearances are coincident with the coagulation of the blood; and those agents which prevent or retard coagulation also prevent or retard these morphological changes of the blood-plates. Of these agencies are to be mentioned a temperature of 0° C. (32° F.), saline solutions, especially sodium and magnesium sulphates, and natural serosities, such as liquor amnii and dropsical effusions.

In the living animal the fact that the blood-plates are the chief factors in the formation of a thrombus may be readily demonstrated by puncturing or slightly cauterizing the wall of a mesenteric vessel. The blood-plates collect at the irritated portion, and speedily form a thrombus, in which are entangled a number of white corpuscles, the blood-plates, however, being largely in excess. The same results are produced in larger vessels by transfixing them with ligatures.

Both Hayem and Bizzozero, while insisting that the blood-plates are the cause of the coagulation of the blood, do not deny that other substances may have a coagulating power, although they suggest that fluids possessing this power in which no blood-plates are visible, may yet contain the products of disintegration of these very destructible bodies. Such a fluid is saliva, and in it the blood-plates are speedily destroyed. Bizzozero remarks at the conclusion of his interesting paper that his experiments speak far more in favor of the coagulative power of the blood-plates than for that of the white corpuscles, but do not exclude the participation of the latter in the process. That the white corpuscles do participate seems incontestible to the writer in view of the experiments of Wooldridge.

From the foregoing remarks it will appear manifest that while the subject of the coagulation of the blood is still incomplete, the whole tendency of modern research is to associate it with changes in certain morphological elements of the blood, particularly the blood-plates and white corpuscles. The term blood-plate has been employed in preference to hæmatoblast, because the latter not only implies a view with regard to the physiological destiny of these bodies which is thus far in need of confirmation, but, in addition, has been applied to a variety of morphological elements, thereby giving rise to much confusion. Thus, besides the use to which it has been put by Hayem, it has been employed by Rindfleisch to designate the nucleated, red marrow-cells (the *cellules hémoglobiques* of Malassez), and has been applied to the vaso-formative cells of Ranvier, and also, by Creighton, to the connective tissue-cells, from which he observed red corpuscles to spring by a process of budding in certain sero-sanguineous cysts of the neck (*Jour. of Anat. and Phys.*, vol. xiv., 1880).

NON-ALBUMINOUS CONSTITUENTS OF THE PLASMA (EXTRACTIVE MATTERS).—*Sugar.*—Glucose is constantly present in the serum. Its percentage is increased by a diet of starch and sugar, but it is formed independently of the food, as proved by the fact that after several days fasting its amount is but slightly diminished.

Urea.—The amount of urea varies between 0.02 and 0.04 per cent.

Besides urea are also found creatin, creatinin, carbamic acid, uric and hippuric acids.

Fat is constantly found. After several days' fast its quantity is from 0.5 to 0.7 per cent. On a fatty diet it rises to 1.25 per cent.

Cholesterin is also a constant ingredient and increases under a fatty diet.

Lecithin exists in the serum as well as in the red corpuscles.

Succinic acid is found in small amount, according to Meissner.

The serum is more or less yellow, and in thick layers, often reddish, when there is not a trace of hæmoglobin to be found in it. This color depends upon a series of pigments, of which the nature of one only is known. This is *Cholepyrrin*, the coloring matter of the bile.

SALTS OF THE SERUM.—The serum contains somewhat less of salts than the liquor sanguinis, on account of the withdrawal of part of the calcium and magnesium phosphates in the act of coagulation. Sertoli gives the following as the result of his analyses :

One thousand parts of serum yield :

	Grammes.
Sodium chloride	5.39
Sodium sulphate	0.24
Disodium hydric phosphate (Na_2HPO_4)	0.05
Na, calculated as Na_2O (existing as carbonate or bicarbonate)	1.16
Potassium sulphate	0.414

ORIGIN OF THE RED BLOOD-CORPUSCLES.

The blood, while retaining a definite composition, is, as regards its ultimate elements, the most unstable of the animal tissues. Products of metamorphosis of the red corpuscles are continually forthcoming in the coloring matters of the urine and bile, while, in the function of menstruation, more or less blood is directly removed from the vessels. In pathological states the entire mass of the blood, or one or more of its constituents, may be greatly diminished, and yet, sooner or later, if the diseased condition be removed, its normal amount and composition are restored. The question of restoration of loss of water, albumins, and salts, presents little or no difficulty, but that concerning the manner and place of regeneration of the red corpuscles, has been, and still, in great part, continues to be, one of the most perplexing problems of physiology.

In the earliest periods of embryonic life, white nucleated blood-corpuscles alone are found, which very soon acquire a reddish tint, due to the acquisition of hæmoglobin. They are derived from the central cells of the newly formed heart and blood-vessels, which are at first solid cords in the mesoblastic layer of the embryo. In these cords a channel is formed by the detachment of the central cells and the secretion of a fluid plasma. These embryonic blood-corpuscles are spherical and average about $\frac{1}{2500}$ inch in diameter. They multiply by subdivision until the period at which lymph is poured into the blood by the thoracic duct, at which time they begin to be mingled with colored non-nucleated disks. From this time on the lymphatic system, in which are certainly included, so far as blood formation is concerned, the spleen, lymphatic glands, and red bone-marrow, perhaps also the thymus, thyroid, and supra-renal glands, is the sole source of newly formed blood-corpuscles.

In 1868 Professor Neumann, of Königsberg, first called attention to certain cells of the red marrow, identical in appearance with the nucleated red globules of the mammalian fœtus. A month later the observation was confirmed by Bizzozero, who announced besides that he had seen in the marrow every form of transition between the white blood-cells and the nucleated red marrow-cells. The fact of the existence of these cells has been substantiated by numerous observers, and the red marrow of the bones is now universally regarded by histologists as a hæmatopoietic organ. Nevertheless, there are different theories as to the origin of the red nucleated cells, and their conversion into the red non-nucleated corpuscle.

1. As to the latter point, Neumann considered the conversion to consist in a gradual disappearance of the nucleus, while Rindfleisch is of opinion that it is extruded. The latest contribution to this subject is by Malassez, who, in an elaborate illustrated article in the *Arch. de Phys.*, 2 série, t. ix., 1882, describes the process as one of protoplasmic budding from the periphery of the cells. This observation of Malassez has received a remarkable confirmation from the domain of pathology. In the *Journal of Anat. and Phys.*, vol. xiv., 1880, Creighton describes a process of blood formation which he observed to take place in the interior of certain sero-sanguineous cysts of the neck. These cysts, in their solid portions, had all the characteristics of sarcomata, but their central cavities contained red blood-corpuscles that were evidently derived by gemmation from the embryonic cells lining their walls. Creighton regards blood formation as the earliest and most deeply rooted function of the mesoblastic layer, of which the *memory* is retained during the whole life of the individual. When from any cause the cells of this layer return to their embryonic condition, their primary blood-making function is resumed.

2. As to the origin of the red nucleated marrow-cells. They were at first regarded by Neumann and Bizzozero, as the result of a transformation of the white blood-corpuscles, but later both these observers expressed themselves upon this point with greater caution. Malassez demonstrates that, with proper modes of procedure, no transitional forms are to be found, and that the behavior of the white blood-corpuscles toward chemical reagents and staining fluids is very different from that of the red nucleated cells, not to mention their different optical properties. He, therefore, decidedly rejects such a mode of origin, and derives the red nucleated cell from certain larger marrow-cells containing little or no hæmoglobin and in which the nucleus is either barely perceptible or quite invisible ; in the latter case, he considers the nucleus to be diffused throughout the protoplasm. He calls this cell the primitive hæmoglobic cell, or proto-hæmoblast. In the course of its development, the nuclear substance condenses and a thin layer of protoplasm encircles it. At this stage the nucleus is very faintly colored by staining substances, such as hæmatoxylin and picrocarmin. Gradually the nucleus contracts, and, at the same time, stains more deeply, and coincident with these nuclear changes the surrounding protoplasm loses its granular aspect and becomes perfectly hyaline, elastic, and rich in hæmoglobin ; in short, acquires all the characters of the red blood-corpuscle. Malassez considers the nucleus of these cells to be of a fluid consistency, and, therefore, to take a passive part in the changes above described, which are all due to the activity of the protoplasm.

These observations regarding the hæmatogenic function of the medullary substance acquire a still greater significance when considered in connection with the discovery by Hoyer that, in the red marrow, the blood from the arteries, instead of traversing a capillary system, passes into the veins through the medium of a system of lacunæ destitute of walls, and thus comes directly in contact with the cells above described. This anatomical observation of Hoyer has been confirmed by Rindfleisch.

Another mode of blood formation in the marrow is by means of giant cells (myéloplaxes), in the interior of which red blood-corpuscles are developed. This mode of blood formation has been observed by Foa and Salvioli in the marrow, as well as in the spleen, liver, and lymph-glands of the embryo and fœtus. It has been observed and fully described by Ranvier as occurring in the omentum of young rabbits, and has been studied by Heitzmann in cartilages in course of ossification and in inflamed bone. Malassez and Ch. Monod (*Arch. de Phys.*, 2 série, t. v., p. 389) have also observed the same processes in certain myeloid tumors which they term angioplastic sarcomas. There are a number of facts tending to prove that the so-called giant cell is concerned in the new formation of blood, and, in consequence, the term angioblast has been proposed for these bodies by Brodowsky.

To the spleen is also ascribed a share in hæmatogenesis. The same transition forms are found as in the bone-marrow, and the same lacunæ between the arteries and veins are still more readily demonstrated. Counts of the blood in the splenic artery and vein show that the latter is richer in red corpuscles.

The lymphatic glandular system, however, is probably chiefly concerned in blood formation. From this source fresh elements are continually introduced into the circulation. It was observed by the late Professor J. H. Bennett, of Edinburgh, that "in chyle taken from the thoracic duct there are also biconcave flattened disks exactly resembling the colored blood-disks in size and form, but destitute of color." This observation has been confirmed and greatly extended by Professsor Richard

Norris, of Birmingham, who describes these bodies under the name of the "advanced lymph-disks," that is, the ultimate cellular product of the lymphatic glands. They are the free nuclei of the uninuclear cells of these glands. In the blood these disks, by the gradual acquisition of hæmoglobin, become converted into the red corpuscles. Norris claims that identical elements are furnished by the spleen, marrow, thymus, and thyroid glands, and this process he terms the major process of blood formation. The white corpuscles of the blood he considers to be lymph-cells which have entered the blood in an immature state. Their nuclei are eventually liberated, become colored, and develop into perfect red corpuscles. This latter process he terms the minor process of blood formation.

M. Hayem claims for his "hæmatoblasts" the principal share in blood formation, and bases his claim upon the following facts: 1. The resemblance of the two in external appearance, particularly as regards the occasional biconcave form of the "hæmatoblasts." 2. The fact that some of the "hæmatoblasts" contain hæmoglobin. 3. Their scarcity in health as compared with their great increase in certain diseases, especially in anæmic conditions and after blood-letting. 4. The presence in the blood of minute biconcave red corpuscles, which he regards as transitional forms.

According to Hayem, the hæmatoblasts average, in healthy blood, 255,000 per cubic millimetre, *i.e.*, forty times more than the white corpuscles, and twenty times less than the red.

On the other hand, Norris admits the presence of red nucleated cells in the marrow (cellules hémoglobiques of Malassez, hæmatoblasts of Rindfleisch), but argues that their numbers are entirely too small to warrant their being regarded as anything more than the remnant of an embryological mode of hæmatogenesis. He also claims that the "hæmatoblasts" of Hayem (the Blutplättchen of Bizzozero) are products of disintegration of his colorless corpuscle.

Although the subject of blood formation is as yet in embryo, its development within the last few years has been remarkable, and there is every reason to hope that ere long it will be as thoroughly understood as any other function in the animal economy. *Frederick P. Henry.*

[1] Lancet, August 18, 1883.
[2] Manual of Mic. Anat. (Am. ed.), p. 704.
[3] See Hermann's Handbuch der Physiologie, Bd. iv., Theil 1, p. 26.
[4] Liquides de l'organisme, p. 268.
[5] Copeland's Dict. of Med., New York, vol. i., p. 228.
[6] See paper on Blood-cell Counting in the Boston Medical and Surgical Journal, April 10, 1879, by Drs. F. P. Henry and C. B. Nancrede.
[7] See paper entitled A Contribution to the Study of Icterus Neonatorum, by Frederick P. Henry, M.D., Archives of Medicine, October, 1883.

BLOOD, AIR IN THE. Circulatory troubles from the presence of intra-vascular gases have been the object of a great number of experiments; few subjects in experimental pathology have been so frequently studied; none is so classical, and none perhaps has been more labored and less advanced. The question is not confined to cases in which air from without has entered the vessels; the facts are of equal importance, no matter whether the gases found after death are developed spontaneously during life in the interior of the vascular system, or have been introduced into it by mechanical means.

A bibliographic review furnishes no plausible explanation to account for the symptoms caused by the entry of air into the blood, and it is easy to see, from the conclusions of different experimenters, that the mechanism of such accidents is far from being established scientifically. From the earliest days of medicine our forefathers were more or less acquainted in an empirical way with the development of intra-vascular gases. To explain these accidents, till the seventeenth century, they made insufflation on animals. The question was then medical and physiological. The theories prevailing in recent times were then put in circulation, but in a hypothetical way, like all empirical explanations. Some admitted cerebral apoplexy; others sustained paralytic arrest of the heart; while others indicated the theory of pulmonary obstruction. In the present century the anatomico-physiological school developed the cerebral theory, which was admitted until 1813, when a cardiac theory was sustained. The question became surgical, and really practical in 1806, with a case observed on a horse, and in 1818 the first case of spontaneous entrance of air in the human subject was observed. Subsequently the cardio-mechanical theory was distinctly formulated, and was sustained and admitted as a classic explanation for a long time, until replaced gradually by the pulmonary theory, which was gradually admitted from 1850, although the cardiac theory had its partisans. In 1837–38 the latter theory was upheld by the French Academy of Medicine in a long dispute, that resulted in many opinions but few facts. In later years a new reaction occurred with the cardio-chemical theory, dating from 1863, and in the mixed cardio-cerebral theory of 1873. It thus appears that the manner in which the presence of intra-vascular gases in the system exerts a prejudicial effect is still a matter of speculation. There is, moreover, little coincidence of opinion among writers as to the immediate cause of death in such accidents. One high authority says that death is from apoplexy; another, equally high, says it is essentially asphyxia; while a third says syncope, and a fourth emphysema. It is not satisfactorily demonstrated that either death of the brain, arrest of the heart, or pulmonary obstruction accounts for the symptoms attributable to the presence of air or gas in the blood. These undecided points are, however, of less consequence than the phenomena observed when a gaseous body is present in the circulation, no matter whether the gas be developed spontaneously in the system or introduced by some artificial means.

The presence of intra-vascular gas may be owing to an abdominal lesion, as a wound of the intestines, or it may be caused by putrid and gangrenous fermentation, and by cadaveric gases developed in the tissues. Among numerous instances in which air is found in the veins after death are said to be deaths from strychnia, from hydrophobia, and from chloroform. It is thought to have occurred from ulceration of the cæcum, gangrene of the great toe, and as the result of gaseous decomposition of clots left in the uterine cavity after labor.

The writer knows of a case of traumatic paraplegia with a large sacral bed-sore, in which air was found in the vena cava ten hours after death. Air may enter the blood by inspiratory efforts that increase the intra-thoracic pressure, and produce a consecutive increase of the endosmotic current, with a diminution of exosmosis. After profuse uterine or other hæmorrhages a certain development of intra-vascular gases may result as a trouble of the osmotic pulmonary exchanges. Atmospheric air may also enter the veins spontaneously during a surgical operation. With a view to experimentation, it has often been forcibly introduced into the vascular system of animals, and the different experimenters have reached conclusions almost as inconclusive as their researches have been diffuse. Much better studied are the curious phenomena resulting from variations of pressure, that have their point of departure in modifications of the solubility of oxygen in the blood, and in the increase or decrease of the pulmonary endosmosis. These phenomena exist during the rapid variations of pressure to which submarine divers and workmen in compressed air are subjected, and expose them to grave accidents. A workman coming suddenly out of a caisson with an increased quantity of oxygen in his blood may experience immediate cardiac symptoms from arterial gaseous emboli, or the sudden decompression may so compromise the circulation that the quantity of oxygen is insufficient to nourish the vitality of the tissues, in consequence of which slow medullary symptoms sometimes occur, with the establishment of a necrobiotic centre and gradual death of the nervous elements, and final arrest of the circulation. Numerous references to such accidents abound in the medical annals, not only of our own, but of foreign countries, and doubtless many physicians may recall the necrobiotic survivors of the Brooklyn Bridge, and of other great constructions necessitating prolonged

labor in compressed air. Aeronauts do not suffer from the sudden variations of pressure to which they are subjected, because the circulation more readily accommodates itself to the gradual change of pressure in passing through the atmosphere than through a dense medium like water. However, among many explanations to account for "balloon sickness," is the insufficient counterbalancing of the heart's action.

Facts having relation to the pathogeny of vascular pneumatosis—which is still incomplete—have been observed in experiments on animals, during accidents occurring in surgical operations, and at the necropsies of cases that have resulted fatally after the sudden entrance of air into the veins. Among the physiological phenomena caused by compressed air all observers have noted the diminution in the number of heart-beats and of the respirations, and an increased amplitude of the latter. But it is decompression and not compression that produces serious consequences. Animals placed in a glass jar and subjected to, say ten pressures, die almost instantly on being restored to normal pressure. The process is explained as follows: On being restored to normal pressure the gases with which the animal's blood is supersaturated become liberated somewhat after the same manner as when a cork is drawn from a champagne bottle; the oxygen with which the blood was charged by the compression combines readily, but the nitrogen is at once set free, and carrying with it carbon dioxide on being disengaged, forms gaseous emboli that arrest the circulation and cause instant death. Another order of symptoms from decompression is found in the mixed cases not immediately fatal, but attended by a peculiar cardiac rattling and immediate paralysis almost general. Men engaged in various industries, as marine diving and sinking piers for bridges, do not suffer from a pressure of one or two atmospheres. Such a pressure is rather beneficial to some; but when greater depth and higher pressure have to be sustained, symptoms of intolerable itching may occur with violent pains in the muscles and joints that have done most work; there may be transient paralysis of the lower extremities, but more often it is persistent and fatal, and finally sudden death may occur. The accidents that take place in a pressure above five or six atmospheres have for their cause poisoning by oxygen. In the case of divers, death never occurs at the bottom of the sea, but on coming to the surface. The depth at which men may work with safety depends on the apparatus employed and on certain precautionary measures. Bell-divers may work at a depth of from thirty to sixty feet, and helmet-diving may be carried on safely at a depth of one hundred and fifty feet. An English diver has made seven descents in two hundred and one feet of water, and remained under forty-two minutes with a pressure of eighty-seven pounds to the square inch. Yet three out of four divers at Swatow are reported to have suffered from curious paralytic affections, with symptoms resembling those of antero-lateral spinal sclerosis, in consequence of working at a depth of only one hundred and forty-four feet; and a company of twenty-four divers in the Grecian Archipelago in one year lost ten men, of whom three died suddenly, and the others becoming paralytic succumbed a few months afterward. Men working in the compressed air cylinders used in building the St. Louis bridge were taken with paralysis of the lower limbs at a depth of sixty feet. The excavation being carried to a depth of one hundred and ten and a half feet below the summer water-level of the river, the pressure was fifty and fifty-one pounds to the square inch; and of three hundred and fifty-two men subjected to the pressure thirty were seriously affected and twelve died.

Gases mixed with the arterial blood, acting mechanically and slowing on the capillary circulation, produce cerebral anæmia with excitation of the grand sympathetic, or better, bulbo-medullary anæmia, and consecutively necrobiosis of the nervous elements with or without hæmorrhage. Although the capillary trouble is general, the nervous element, being more sensitive, is alone altered; the arrest of nervous functions resulting in consecutive respiratory arrest and ultimate arrest of the circulation. General excitation of the grand sympathetic, augmentation of tension, relaxation of the sphincters, etc., with slowing of the heart, are symptoms entirely opposed to those that occur on the entrance of air into the veins, where there is a fall of tension with acceleration of the heart. Gas in the arteries is a relative trouble, and produces paralytic symptoms only when introduced in large quantity; when liberated or evolved in small quantity it leads to no appreciable trouble. The introduction of air into the carotid leads to death from paralysis of motion and of sensation, from rhythmical convulsions, and from spasms of the respiration. Injections of air into the abdominal aorta always bring about symptoms of paraplegia. The passage of air into the circle of Willis by injection into a collateral of the carotid leads to paralysis of motion and sensation, with predominance of the signs on one side or the other, and to sensorial disturbances. The action of air in the arterial system manifests itself by mechanical arrest of the circulation in certain capillary regions, and principally in the more delicate ones of the central nervous system. Gas in the veins is, however, a cardiac functional trouble, causing immediate arrest of the circulation and consequent death of the organs. Dogs, horses, and other animals are killed instantly if air be injected into the veins suddenly; but if it be injected slowly, a large quantity can be borne without fatal effect. From numerous observations on animals in which air has been forcibly introduced into the venous system, it appears that, at first, there is a diminution of the aortic wave with cardiac acceleration. Later a more considerable fall of tension occurs; respiration is accelerated, and there is syncope, with fall, cry, etc. Afterward the aortic wave is absent, or nearly so; there are muscular contractions, convulsions, and cerebral anæmia; then bulbar anæmia and infrequent respirations. Absence of tension follows, with death of the brain and arrest of the respiration, and last, cardiac arrest. The spontaneous introduction of air into the veins may suddenly arrest a surgical operation with dangerous symptoms and fatal results, especially if the operation be in the region of the cervico-thoracic veins. During the course of an operation on the neck, the face, or in the axilla, after an accidental or a self-inflicted wound of these regions, or on opening a cerebral sinus, the hepatic veins, and in animals the spinal canal, a peculiar, characteristic hissing, gurgling sound is heard if air be introduced by the thoracic aspiration, and the patient, perhaps, with a sudden scream, falls faint and insensible; a tetanic convulsion may occur, and death is almost instantaneous. Sudden and startling accidents of this kind have occurred not only after operations on the summit of the thorax, but after amputations at the shoulder-joint, upon opening an abscess of the thigh, and in uterine surgery. In most of the reported cases of the introduction of air into the veins the effects have been sudden and appalling. On opening a vein in the neck, the axilla, or a large cervical absorbent vessel, patients have been known to tremble and die suddenly, without either sigh, groan, or struggle. Among other physical signs that have been noticed during such accidents are a bubbling, thrilling, rasping sensation conveyed to the hand on applying it to the chest; a loud, churning noise in the breast synchronous with the ventricular systole; a scarcely perceptible pulse, and widely dilated pupils. The air in such cases enters the open veins by the suction action caused by the inspiratory expansion of the lungs, which empties the veins and causes their contents to pass into the right side of the heart, instead of the lungs. The walls of the ventricle contracting on an elastic gas, or a frothy mixture of gas and blood, and not on an incompressible liquid, the cardiac mechanism is disturbed, there is a reflux of blood into the veins, the wall of the ventricle is distended in virtue of the intra- and extra-venous difference of pressures, and a sort of acute systole with tricuspid insufficiency causes prompt arrest of pulmonary action. Fatal arrest seems to be caused not by want of air in the lungs, but want of blood in the pulmonary vessels. The introduction of air into veins at a greater distance from the heart is just as dangerous, but these vessels not being

under the immediate influence of the respiratory organs as are the cervico-thoracic veins, thus explains the infrequency of the occurrence. The mechanical conditions calculated to cause the entrance of air into the patulous mouths of the uterine veins exist after delivery. Air may enter the circulation through the uterine sinuses after delivery and produce its characteristic effects. Rabbits, with successive inversions of the uterus after parturition, have been observed to die suddenly from the effects of vascular pneumatosis. The fact that air may enter the veins of the human subject through the uterus is now unquestioned in medical science. The accident may occur not only after parturition, but in uterine carcinoma, after uterine injections, and after blowing air into the uterus to produce contractions and abortion. The former habit of injecting carbon dioxide into the uterus had to be abolished on account of the fatal effects following its entrance into the circulation. The possible introduction of air into the veins by means of the air pessary renders its use objectionable under certain circumstances. The mechanical conditions under which air obtains entrance into the uterine veins in such cases are the same as for the more dangerous region. Respiratory movements being transmitted to the uterus by the flux and reflux of the intestines, inspiration empties the veins and aspiration will occur at its neck if it do not contract sufficiently to close the orifices of the open vessels. It is estimated that two-thirds of the patients to whom these accidents happen die; one-half in a few minutes, and the others after a few hours or several days. It is stated that after recovery from the immediate symptoms there is a tendency to bronchitis or pneumonia, but this assertion has been doubted by some.

The manner in which death occurs from the introduction of air into the blood, although of little practical consequence, has been fully as much discussed as the more evident and interesting fact that air in the heart proves fatal. The proximate cause of death still admits of an acceptable explanation. Most of the theories of experimenters to account for the fatality are open to objections more or less weighty, and many of them are physiologically incomprehensible when taken in connection with the kymographic tracings obtained during experiments on animals and with the facts observed at the necropsy. It seems, however, that the circulation is always the first and the only function that is directly modified. Immediate fall of tension, by arrest of the aortic wave, constitutes the initial trouble, and coincides with the disturbance of the heart's action. All the general troubles consecutive on the entrance of air are symptoms of arrested circulation following the primitive and constant trouble, arrest of the aortic wave, and have no special relationship to the entrance of air alone. In fact, late writers assert that the introduction of air into the venous system is almost always without danger, for the air only kills in so far as it makes an equilibrium by its tension to the contractile power of the right heart, which may be estimated at the pressure of a column of water thirty-five centimetres high; that this tension is not really a phenomenon inherent to the cardiac and respiratory mechanisms, as authors think, but is simply produced by the aid of the injecting apparatus by the operator himself; and that primitive distention of the heart cannot produce, by the fact alone, the dangerous symptoms attributable to the entrance of air, which are nothing more nor less than the result of artificial experimentation.

The signs observed after death following the introduction of air into the veins, have a general similarity. Air, or a spumous mixture of air and blood, is found in the right heart, and bubbles are found in the cerebral venous sinuses, in the large venous trunks, and in the arteries. Experimental verification may be made in the case of a decompressed cat or other small animal. In decompressed animals there is also a general uniformity in the post-mortem appearances, which confirm the disengagement of free gas in the circulatory system. The blood of all parts of the body gives off bubbles under mercury; and by aid of the microscope bubbles are discovered entangled in the capillaries. There is, besides, an entire absence of hæmorrhage into the brain or spinal cord. Further necroscopic appearances in surgical cases are venous engorgement and paleness of the lungs. The conditions vary when life has been prolonged after the accident. Air may then be found in the left heart and systemic arteries, a frothy mixture of air and blood in the right heart, the systemic veins, the pulmonary arteries, and their branches. Excessive proportion of blood in the systemic veins over that of the lungs and arteries, seems to establish the fact that the circulation is arrested in the right heart. The causes of death appear to be enormous distention of the right chambers of the heart, hinderance of the pulmonary circulation from viscosity of the air, and compression of the brain by air shut up in the encephalic veins.

The entrance of air into the veins during a surgical operation is, perhaps, not so common nowadays as it was before the introduction of anæsthesia, and the cases are rare in comparison with the number of operations that seem to favor the accident. Yet the possibility of such an occurrence is of sufficient importance to be borne in mind, particularly in operations on that part of the neck known as the dangerous region, and it should be guarded against in bronchotomy, in transfusion of blood, and even in hypodermic medication, which may be followed by alarming symptoms on the forcible introduction of a small bubble of air from the syringe. The accident is, doubtless, favored by deep inspirations, by the lowered condition of the vital powers during or at the close of an operation, by the morbid condition of the parts through which the veins pass, by spasmodic contraction of the muscles, and by structural changes in the veins themselves. Other circumstances favoring the accident are traction and position, either of which may convert the vein during an operation into an open-mouthed, gaping tube.

The means to prevent the dangers attributable to the entrance of air into the veins during an operation, and the treatment to be pursued in such an event being detailed in surgical manuals, their reproduction here would be but a needless repetition of well-known operative maxims and of the resources generally opposed to syncope. On this point we are reduced to the painful condition of a police judge facing a criminal against whom there is no evidence. Indeed, it is doubted by some whether air ever enters spontaneously into the wounded veins, except in very small quantity, and the sudden deaths attributable to spontaneous entry of air into the veins in a surgical operation are equally doubted.

But the phenomena of compression and of decompression have been better studied, and the fact that the advantages offered by compressed air are applicable to a wide range of engineering operations, makes the safety of workmen engaged in these operations a question of more practical hygienic importance.

Most of the dangers incident to workmen in compressed air may be averted or considerably lessened by the adoption and enforcement of judicious prophylactic measures. Something like military control should be had over the men employed, who should be selected after the manner of recruits. As a general rule, they should be between twenty and forty years, and all fat men, drunkards, and those having any affection that may be aggravated by the action of compressed air should be rejected. The men are not to descend into the caisson fasting, nor while suffering from coryza, intermittent fever, rheumatism, or any affection of the heart or breast. The spells of work below should not consist of more than two, of six hours each, in the twenty-four, and new hands should at first have but two turns below of two hours, which may be gradually increased. It has been shown that the symptoms have immediately lost their gravity and frequency on diminishing the working hours, and on slowing the decompression. The locking out, which is really the exciting cause of the symptoms, is not to be done hurriedly, and the air-lock should be at the top rather than at the bottom of the shaft. The danger from ascending a long flight of stairs immediately after quitting the air-lock, may be averted by substituting a steam lift, as was done in the St. Louis and

the New York caissons. On coming out, the men should be provided with hot drink, a hot bath, and warm clothing, and they should rest in a dormitory provided for the purpose. There should also be placed at their disposal a sufficient quantity of warm water for bathing purposes. The hot bath has been objected to by some American physicians, but lately, during the work on the new graving docks at Toulon, which necessitated a great deal of prolonged submarine labor, its use has been found one of the most efficacious of hygienic measures. In addition to cleansing away the mud, etc., with which the men are always more or less soiled in coming from the caisson, the hot bath was found to relieve fatigue, and to regulate and revive the circulation. It was, moreover, useful in treating the pains and other accidents caused by decompression. It is important that regularity in sleep and other matters of personal hygiene should be observed, and there should be plenty of meat and coffee at meals. Warmth may be introduced by means of a steam-coil, as was done in the New York caisson of the Brooklyn Bridge, and the vitiation of the atmosphere may be greatly remedied by the use of the electric light.

The greater part of the symptoms produced during compression are of so little gravity as not to merit notice, and generally vanish on return to the open air. Pain in the ears may be made to disappear mechanically by clearing the Eustachian tubes by the movements of deglutition, and by strong expiration, the mouth and nose being closed. If the pain persists it is usually relieved by the introduction of a dossil of lint or cotton soaked in laudanum. Headaches, and in general all pains resulting from compression, yield rapidly to the local application of anodynes.

Unhappily, the more serious results of decompression are not so easily dealt with. Congestion of the deep viscera, of the encephalon and spinal centres, during compression and at the moment of decompression, are now generally admitted by authors, as well as the presence of gas in the blood, which reappears in a free state under the influence of decompression, and occasions symptoms comparable to those produced by the injection of air into the veins. Hæmorrhagic imminence and tendency to emphysema translate themselves into facts in the hæmorrhages and emphysemas observed in ascending high mountains, in balloon ascents, and in the sudden exit from a caisson, or from a deep-sea pressure. Persons familiar with deep-sea dredging have seen fish burst on coming to the surface, and a dog has been observed to become absolutely cylindrical from subcutaneous emphysema following instantaneous decompression. Attributing sufficient intensity to the expansive force of gases thus set free, a decompressed man is somewhat in the situation of a bottle of water charged with carbon dioxide, and the disengagement taking place in the substance of the tissues and in the sanguineous liquid lead to the conclusion that the exaggerated tension may account for the hæmorrhage and lesion of the cord with consequent paralysis, and other troubles observed among the accidents of decompression.

The treatment of these cases will depend upon the symptoms and their severity. To relieve the pains in the limbs the patient should be put in a hot bath, and massage energetically applied, with a view to increase circulation and facilitate absorption of the air-bubbles and disappearance of the capillary emboli. On coming out of the bath the patient should be rubbed with some sedative solution, in order to bring on rubefaction and consequent derivation by the skin. An effort should be made to bring about abundant perspiration by wrapping in a warm blanket and administering some hot drink, or the acetate of ammonia. Drachm doses of ergot have been used with benefit in relieving the pains. In case of paralysis the best means to re-establish the circulation and to combat congestion is by recompression. Light cases are cured by gradual recompression, followed by very slow decompression. A special apparatus built for the purpose can be connected with the pipe that conveys air from the condensers to the caisson. Good results may also be obtained by inducing an energetic derivation and a depletion of the deep organs by the use of cups to the lumbar region, and the application of the exhausting apparatus to the lower extremities.

Irving C. Rosse.

BLOOD, CIRCULATION OF THE. *The circulation of the blood* is its rhythmical and continuous movement in one direction through the heart, arteries, arterioles, capillaries, and veins. The fundamental cause of the circulation is the difference between the hydrostatic pressures existing in these various channels; the greater this difference the more rapid the blood-current becomes.

(For a more complete understanding of the subject, the articles upon the Composition of the Blood, and Anatomy and Development of the Heart and Blood-vessels should be consulted.)

The uses of the circulation are: 1, to distribute oxygen through the system; 2, promote nutrition; 3, remove waste products; and 4, equalize the body temperature.

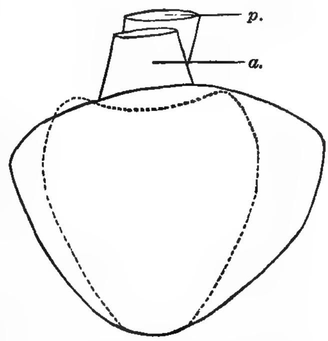

FIG. 445.—Posterior Outline of Dog's Heart in Systole and Diastole. *a.*, aorta; *p.*, pulmonary artery. (After Hesse.)

The course of the circulation starting (for example) from the right ventricle, is through the pulmonary artery to the capillaries of the lungs, through the four pulmonary veins to the left auricle, thence into the left ventricle, from which the blood is forced into the aorta and passes through the arteries, arterioles, and capillaries in the various parts of the body; returning by the veins to the right auricle, it re-enters the right ventricle, when the circuit is repeated. The short course through the lungs is spoken of as the "lesser circulation," and the course through the system at large is the "greater circulation."

The principal agent in propelling the blood is the rhythmical contraction of the heart, which is repeated, upon the average, seventy-two times a minute in the adult male. Accessory agents are: 1, the contraction of the arteries and of, 2, the muscles among which the veins lie; 3, aspiration of the chest; 4, capillary attraction; 5, osmosis caused by chemical tissue-change.

THE HEART.—*Changes in Form.*—If the heart of a calf or other mammal be exposed and kept beating while artificial respiration is maintained, a very rapid peristaltic movement will be seen to pass from the cardiac end of the vena cava over the auricles to the ventricles. At the same time the transverse diameter of the heart is shortened by about one-third (Figs. 445, 446), the antero-posterior is shortened by about one-half (Figs. 447, 448, Hesse); and the long diameter is shortened very slightly (Curtis) (Figs. 447, 448), by the ventricular contraction and by the descent of the base of the heart, which is immediately pulled up again by the elasticity of the great vessels arising from it. The base of the heart changes from an irregular oval to a circle. After a brief pause called the "diastole," this process is repeated. The

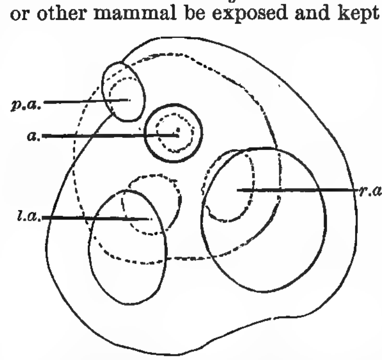

FIG. 446.—Outline of Base of Dog's Heart in Systole and Diastole. *p.a.*, pulmonary artery; *a.*, aorta; *l.a.*, left auriculo-ventricular opening; *r.a.*, right auriculo-ventricular opening. (After Hesse.)

peristaltic movement is so rapid that, unless the heart beat very slowly, it may appear as a single firm contraction of the entire heart-muscle. This contraction is called the "systole."

Changes in Position.—During the systole the whole heart rotates slightly forward and inward on its long axis (lateralem inclinationem of Harvey, 1628), owing to the spiral arrangement of its muscular fibres. When the blood is forced into the aorta and pulmonary artery it elongates them by its pressure, and as the heart is suspended by these vessels it is said that they thus depress it downward and forward at that instant (Senac), giving a "reaction impulse;" v. Ziemssen and others claim that the heart moves upward and to the right during contraction. The movements of the heart have been much disputed, and this is owing to the altered conditions which unavoidably obtain when the chest-wall is opened. The heart is then free to beat more violently and move more extensively, and the necessity for maintaining artificial respiration in all large animals constantly interferes with its movements by the exaggerated motion of the lungs.

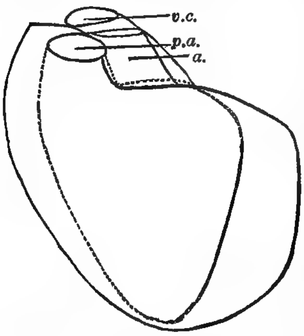

FIG. 447.—Outline of Left Side of Dog's Heart in Systole and Diastole. *v.c.*, vena cava; *p.a.*, pulmonary artery; *a.*, aorta. (After Hesse.)

The Impulse-beat.—If the heart be held in the hand at the commencement of ventricular contraction, it becomes suddenly very firm, owing to the pressure of the cardiac muscle upon the practically incompressible blood within the ventricles, and it is this sudden tension of the ventricles which is felt through the chest-wall where the right ventricle comes in contact with it, usually in the fifth left intercostal space, about five centimetres below the nipple and 1.2 ctm. to 2 ctm. nearer the sternum than the nipple. The exact point varies considerably with changes in the position of the chest. This impulse-beat is usually termed the "apex-beat." It is, however, disputed whether the apex itself normally strikes against the chest-wall, or whether the impulse is caused by the portion of the right ventricle immediately above the apex. A needle placed in the apex shows merely a vibratory thrill without change of position. C. Ludwig and Kiwisch claim that the apex does strike the chest-wall with each cardiac contraction.

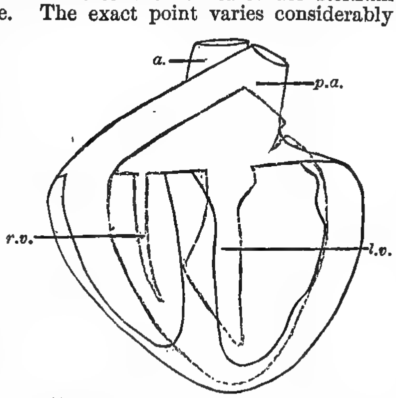

FIG. 448.—Anterior Outline of Dog's Heart in Systole and Diastole. *a.*, aorta; *p.a.*, pulmonary artery; *r.v.*, right ventricle; *l.v.*, left ventricle. (After Hesse.)

When the *heart-muscle* contracts, its fibres shorten in long diameter and lengthen in transverse diameter. These fibres are striated and have a peculiar anastomosis (consult article Anatomy of Heart). It is not known whether their contraction is simple, or of a compound tetanic nature; it is, however, eight to ten times as long as the contraction of a skeletal muscle, but neither tetanus nor tonus can be maintained for any length of time. When the ventricles beat feebly they contract more slowly.

The *nerve-supply* of the heart is derived from the (1) cardiac branches of the vagus, which receives some filaments from the accessorius (Ranke); (2) branches from the superior and inferior laryngeal nerves; (3) the last cervical ganglion (often the three cervical ganglia); (4) the first dorsal ganglion; (5) from branches of the pulmonary plexus, chiefly on the right side; and (6) occasionally a branch from the descending part of the hypoglossus (Luschka).

Intra-cardiac ganglia are found in, 1, the septum atriorum and around the coronary arteries; 2, the auriculo-ventricular groove (Bidder's ganglion), and, 3, around the entrance of the vena cava into the auricle. Remak's ganglion occurs in the frog, and probably in other animals, in the sinus venosus. The most careful search has revealed no ganglia in the ventricular septum or apex. These ganglia are probably automatic (Remak), inhibitory (v. Bezold, Traube, Burdon-Sanderson), and accelerating in function. This has been largely determined by the varied action of cardiac poisons, especially alkaloids. (See Dublin *Journal of Medical Sciences*, October, 1883.)

The ganglia are never macroscopic, but consist of scattered unipolar cells, with a few which are bi-polar (Schweigger Seidel). They are all in more or less intimate connection with each other, and with the external cardiac nerves. Excised fragments which include no ganglia, from the hearts of batrachians and of certain mammals, will pulsate independently (Stannius); but fragments which have ganglia attached are more readily excited to contraction (Landois). The strongest ganglionic centre lies in the auricular septum; if this be paralyzed by opium, the cardiac contraction is reversed, and passes from ventricles to auricles. If auricles and ventricles be separated by transverse incision, they pulsate independently and at different rates.

Cardiac Stimuli.—If the heart of a cat, rabbit, or Guinea-pig be quickly removed, it will continue to pulsate rhythmically for ten or fifteen minutes, and under favorable conditions for a much longer time. When the contractions become feeble or intermittent, they may be increased by mechanical, thermic, electric, or chemical stimuli—the latter may be gaseous, or solutions of various drugs.

Experiments with Local Cardiac Stimuli.—The excised heart of a terrapin, which has just ceased to beat, can be made to pulsate again rhythmically after pricking it with a needle at regular intervals. The excised heart is more easily excited by any stimulus to reflex contraction applied to its inner than to its outer surface. Independent rhythmical contractions of the large veins emptying into the auricles have been observed in frogs and rabbits after excision of the heart. In the mammalian heart the auricular and ventricular muscular fibres are entirely independent of each other, and hence any influence exercised by the auricles over the ventricles is a purely nervous impulse (Schelling). The apex of the heart, if cut off, may be stimulated to give a single contraction (Landois). The heart entirely deprived of blood will still beat rhythmically aside from the body, and yet ligation of one coronary artery in a dog in two minutes causes the regular cardiac contractions to give place to fibrillar twitchings, and that ventricle is first and chiefly affected whose coronary artery has been ligated (Sée). There seems to be a certain amount of reserve energy in the heart which is called into play to overcome the altered stimulus of pathological conditions. Direct stimulation of the intra-cardiac ganglia excites the excised heart to livelier action, but brings it sooner to rest, when a fibrillar twitching persists for a while. The heart beats longest in pure oxygen, and stops very soon in an atmosphere of chlorine or carbon-dioxide. External pressure over the heart causes it to beat more vigorously, or alters its rhythm. This is noticeable where a distended stomach in flatulent dyspepsia presses the diaphragm against the heart. A blow on the abdomen will stop the heart of a frog by reflex inhibition conveyed through the sympathetic nerves. The heart may be stopped by severe pain, or momentarily by a full inspiration (in some persons), by altering the

intra-thoracic pressure. Considerable variations in arterial pressure have no effect upon the pulse-rate of the isolated dog's heart (Martin). Severe hæmorrhage increases the frequency of the pulsations. Moderate heat applied to the excised heart greatly increases its rapidity and force of action. In fevers, the warmer blood may be a cause of increased frequency of pulsations. Cold slows the action of the heart, and at 4° C. it stops beating. Cold blood injected into the circulatory system of a dog reduces the pulse-rate decidedly. Bile-acids, present in the circulation, cause slowness and feebleness of heart action (Röhrig, Ranke).

(For further variations in the rate of heart-beats dependent upon age, sex, time of day, position, food, drink, emotion, temperament, exercise, sleep, atmospheric pressure, etc., consult article on Pulse.)

The heart of the dog has been kept alive for many hours (while still connected with the lungs) by artificial respiration and blood-supply, with an apparatus ingeniously constructed by Professor Martin, at the Johns Hopkins University; and many interesting experiments regarding the influence of blood-pressure on the heart action, etc., were made. (Consult "Philosoph. Trans. Royal Soc.," 1883, p. 663, and "Studies from Biolog. Lab. Johns Hopkins University," vol. ii., Nos. 1 and 2, p. 213.)

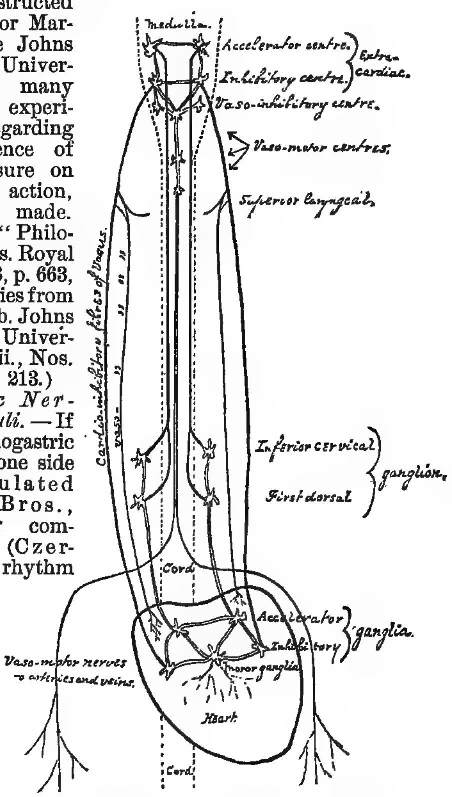

Fig. 449.—Diagram of the Cardiac Nerve Mechanism. (Modified from Yeo.)

Extrinsic Nervous Stimuli. — If the pneumogastric nerve on one side be stimulated (Weber Bros., 1843), or compressed (Czermak), the rhythm of the heart is altered. The contraction becomes more forcible and the period of rest is prolonged. If the stimulus be increased, or applied to both vagi, the heart will stop in full diastole. This action is not instantaneous, but occurs after a latent period (Donders). If the nerves extending to the heart from the lower cervical and first dorsal sympathetic ganglia (Fig. 449) be stimulated, the rapidity of the heart-beats is increased (v. Bezold). The action of the vagus is regarded as controlling or inhibiting the accelerating impulses of the cardiac ganglia, with which its terminal branches, no doubt, connect. The vagus is the trophic nerve of the heart (Gaskell, Eichhorst), and a few accelerator fibres probably exist in it. Afferent impulses travel from the heart to the medulla along the cardiac branch of the superior laryngeal nerve (nervus depressorius). Irritation of the central end of this nerve diminishes arterial pressure, but has no effect on the frequency or character of the heart-beats (Bernstein, Burdon-Sanderson). A nerve-centre exists in the floor of the fourth ventricle which, when irritated, produces the same effect as irritation of the vagus; hence it is called the *extra-cardiac inhibitory centre.* All inhibitory action upon the heart is paralyzed by atropina. A similar extra-cardiac accelerator centre is described (v. Bezold), which furnishes impulses that travel along the spinal cord to the last cervical and first dorsal ganglion, and thence to the heart. The cord itself is said to act as an accelerator centre (Stricker, Wagner). Evidence is lacking of the natural activity of the accelerator nerves (Foster), and they are not antagonistic to the vagi, although they may be controlled by it. In the frog the heart is only supplied from without by the vagus. These extra-cardiac centres are very near the respiratory centre, and it is probable that they too are influenced by the amount of oxygen contained in their blood-supply.

The *ultimate cause* of the heart-beats is entirely unknown. The mechanism is seen to be very complicated, and to be only partially under the control of extrinsic stimuli.

Action of Auricles and Ventricles.—The two auricles contract simultaneously; before their action is over, and about one-tenth of a second after it commences, the two ventricles contract in unison. The ventricular contraction occupies four-tenths of a second, no matter what the rate of the heart-beats may be (Kirke). In the case of Frau Serafin, whose heart was exposed during life, von Ziemssen and Ter Gregorianz obtained cardiographic tracings from the auricles which showed that they kept on contracting for a very short time after the ventricular systole had commenced. In certain pathological conditions the two ventricles may not contract quite synchronously. In the exposed heart of the calf these phenomena are well observed. As the heart beats more and more slowly, there is a marked interval between the auricular and ventricular contractions, and in many animals there will be two or three auricular systoles to one ventricular. The ventricles then cease contracting, and, next to them, the left auricle stops entirely; finally, the right auricle stops as a whole, but a most distinct peristaltic movement may be followed along the auricular appendix (*ultimum morens*, Galen, 1550), which finally gives place to a gentle fibrillar tremor, and the heart is at rest. Dyspnœa, if prolonged, makes the left ventricle beat feebly sooner than the right, so that the left side of the heart becomes congested. This dams back the blood into the pulmonary veins, a probable cause of pulmonary œdema in the death agony (Mayer). The left ventricle contracts with more than double the force of the right, and its walls are three times as thick, for it has far greater arterial resistance to overcome. The systolic pressure of the right ventricle in the horse is 25.0 mm. Hg., in the left ventricle 128 mm. Hg. Fick found that in the dog the systolic pressure of the right ventricle was 18.0 to 42.0 mm. Hg., and of the left ventricle 140.0 mm. Hg. These values are only relative.

Duration of Auricular and Ventricular Contraction.—With sixty-five pulsations to the minute the auricular contraction occupies 0.177 second, the ventricular 0.34 second, and the diastole 0.4 second. With very rapid pulsations the ventricular systole occupies only 0.199 second (Landois). The time shortened, however, in a rapidly beating heart is usually said to be mainly at the expense of the diastole (Donders, Chauveau, Burdon-Sanderson).

The Auriculo-ventricular Valves: Structure.—The auricles are separated from the ventricles by valves which open toward the latter. These valves consist largely of tissue which is the continuation of fibrous rings (annuli fibrocartilagenei), to which they are firmly attached; they also contain near their auricular surfaces a layer of elastic elements derived from the auricles, and some striped muscular fibres (Reid, Gussenbauer, Kürschner). These radiating muscular fibres contract synchronously with the auricles, and retract the valves toward the fibrous rings, and thus enlarge the opening for the passage of the blood. Paladino says that these fibres can also raise the valves during ventricular systole, and also that long fibres pass into the valves from the ventricles. The concentric fibres at the attachment of the valves have a sphincteric action, and prevent too great a strain upon them during ventricular systole (Landois). Blood-vessels have been

found in the valves only where muscular fibres exist (Langer). A lymphatic network reaches toward the centre of the valves (Eberth, Belajeff). The nerve-supply of the valves is not clearly demonstrated. Their entire surface is covered by a layer of tessellated epithelium, a reduplication of the endocardium.

The Cusps of the Valves: Structure.—Each of the two auriculo-ventricular valves is divided into several segments or cusps which have the general shape of isosceles, spherical triangles, whose bases are attached to the heart-wall in nearly the same plane, and whose remaining sides are free in the lumen of the ventricle. The right auriculo-ventricular valve is the "tricuspid;" it has three main cusps, and one or two lesser ones in each of the angles between them (Fig. 450). The left auriculo-ventricular

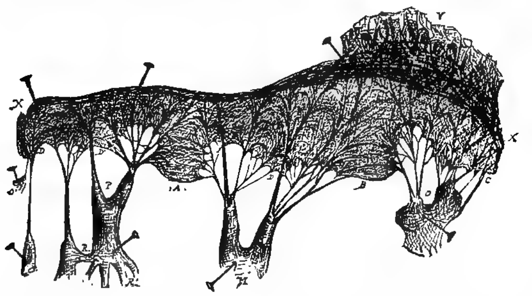

FIG. 450.—Human Tricuspid Valve. Ventricular surface spread out flat. A, inferior; B, anterior; C, septal segment; D D′ D″, lesser segments; M, anterior papillary muscle; O O′, papillary muscles attached directly to ventricular septum; P, papillary muscle attached to columnæ carneæ; R R′v, portion of r, ventricular wall, showing bundles of fibres continuous with chordæ tendineæ; X X′, line of insertion of segments into auriculo-ventricular ring.

valve (valvula bicuspidalis) is the "mitral;" in man this has one large cusp attached on the side of the aortic orifice; a second one, about half the size and opposite to it, and two or three lesser cusps (Fig. 451). The segments of each valve are made continuous with each other at their lines of attachment by a portion of valvular tissue about 0.3 or 0.4 ctm. wide.

The Chordæ Tendineæ: Structure.—The ventricular surface of each segment affords attachment to long, fibrous cords, called chordæ tendineæ, that arise from pyramidal muscles—musculi papillares—which project from the walls of the ventricle into its lumen. Some of the pyramidal muscles spring directly from the ventricu-

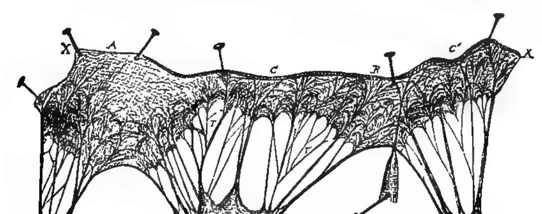

FIG. 451.—Human Mitral Valve. Ventricular surface spread out flat. A, largest cusp close to aortic valve, aortic segment; B, next largest cusp, parietal segment; C C′, lesser cusps; M, anterior papillary muscle; P P′, posterior papillary muscles; T T′, method of branching of chordæ tendineæ; X X′, line of insertion of cusps into auriculo-ventricular ring.

lar walls (Fig. 450, O O′), but others are attached by broad muscular bands—columnæ carneæ—(Fig. 450, R R′) which admit of great elasticity. The object of the chordæ tendineæ is to restrain the segments of the valves from being pushed outward from the ventricles into the auricles during ventricular systole. The pyramidal muscles are situated for the most part opposite the clefts between the segments, rather than directly in line with the segments (Fig. 450, M, Fig. 451, M); this enables the chordæ to spread out somewhat after the fashion of clustered columns in Gothic architecture, and to send branches (Fig. 451, T T′) from a single muscular pyramid to the margins and ventricular surfaces of two different segments, thus affording great mechanical advantage. There are in each ventricle four principal musculi papillares, and a few smaller ones, and several of these muscles are surmounted by two to five lesser cones, from the sides and apices of which the chordæ arise singly or in groups of two or three (Fig. 450, P, Fig. 451, M). At about the middle of their length the chordæ split into radiating branches, some of which anastomose with each other, but which, for the most part, keep on bifurcating until after entering the structure of the valve itself (Fig. 451, T T′), where they form an intricate meshwork of fibres interlacing in all directions. The blood, in circulating among the chordæ, is thrown into a number of vortices. The average length of the individual chordæ inserted into the mitral valve exceeds by one-half or three-fourths the length of the tricuspid chordæ. There is a mechanical reason for this, in that the mitral segments are very unequal in size, and in closing and opening they require more latitude than do the tricuspid segments. They are very strong; a single human chorda, under a strain of over fifty pounds, will always tear out its papillary origin or valvular attachment before it is itself ruptured (Thompson). They are very slightly elastic; the longest chordæ of the human heart are 3.5 centimetres in length, and under a strain of ten or twenty pounds they only stretch 0.3 to 0.5 centimetre (Thompson). The thickest chordæ are said (Oehl) to contain a few striped muscular fibres.

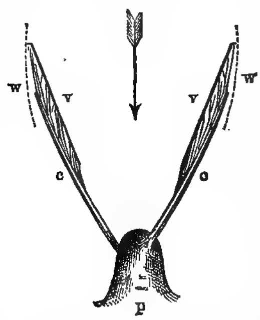

FIG. 452. — Diagram of Mitral Valve, Opened, seen in perpendicular section. c c, chordæ tendineæ, folded somewhat together, but still tense; P, papillary muscle; v v, two cusps of the mitral valve, in perpendicular section; w w, outline of left ventricular wall. The arrow marks the direction of the entering blood-current.

The Chordæ Tendineæ: Mechanism.—The chordæ are always kept tense by the action of the papillary muscles. During the systole of the ventricles the size of their cavities grows, of course, smaller and smaller, and the points of origin and insertion of the chordæ would tend to approach each other, and, therefore, slacken the chordæ; but the papillary muscles themselves contract and diminish in length, and so maintain the proper tension by drawing down the points of insertion of the chordæ. (See D. Macalister in *British Medical Journal*, October 28, 1882, p. 825.)

The Auriculo-ventricular Valves: Mechanism.—The valves are opened by the stream of blood which pushes against their auricular surface. They are, probably, also drawn down by the chordæ and papillary muscles when the ventricles relax, and they are prevented from flapping back and adhering to the ventricular walls by the tension of the chordæ, which hold them out a little (Fig. 452). At the same time the chordæ fold somewhat together, after the manner of the ribs of an umbrella.

The valves are closed by the contraction of the ventricles, which presses the blood in between the cusps and the walls, and forces the cusps toward each other. It is also said that, being lighter than the blood, they are floated upon it (Pettigrew and others). This would hardly seem to hold true in the majority of animals, in which the heart lies horizontally. The muscular fibres attached to the segments and contained within them may assist in their closure (Paladino). The auriculo-ventricular ring narrows during systole, and the result is a slight crumpling of the cusps, the angles between the larger segments being filled by the lesser cusps, which are pressed firmly into them. Hence it is that, viewing a closed valve from the auricular side, the line of coaptation of its segments ap-

pears very irregular, and in the case of the mitral valve it forms an irregular crescent (Fig. 453); moreover, the auricular surface of the valve is not perfectly flat, but is undulating, owing to the branching method of insertion of the chordæ, which allow of the valve being unevenly stretched, its thinner parts yielding more. The segments do not overlap in closing, but their auricular surfaces are

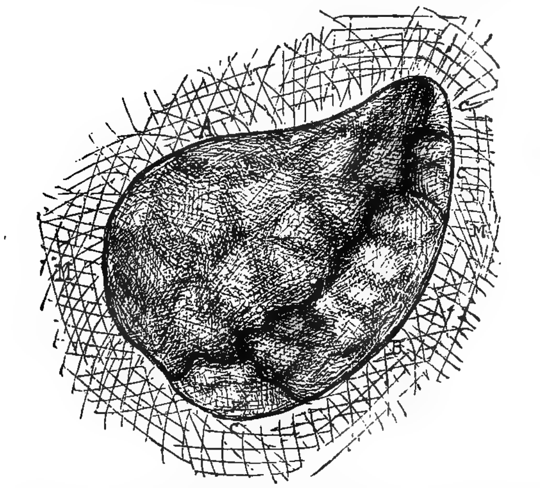

FIG. 453.—Mitral Valve of Bullock, Closed, as seen from left auricle, showing line of apposition of cusps and their uneven surface. *A*, largest cusp ("aortic cusp") attached near the aortic valve; *B*, next largest, or "parietal cusp;" *C C' C''*, lesser cusps filling in the angles between the larger ones; *M M*, auriculo-ventricular ring.

pressed together for a considerable space (Fig. 454). The half of each cusp which is most distant from its attachment is much thinner than the remaining portion, and a large part of this thin half is pressed against the corresponding auricular surfaces of the opposite cusps. The half of the largest mitral segment which is nearest to the line of attachment is smooth, and the chordæ are not inserted into its ventricular surface (Fig. 451, A), an arrangement which diminishes friction as the blood flows over it into the aorta.

As soon as the auriculo-ventricular valves are closed and the pressure in the ventricles becomes greater than in the arteries, the blood contained within them passes out into the arteries; the blood from the left ventricle enters the aorta, the blood from the right ventricle enters the pulmonary artery.

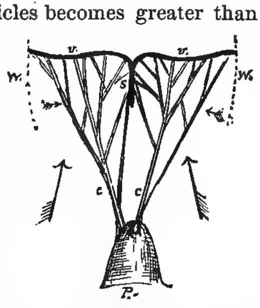

FIG. 454.—Diagram of Mitral Valve, Closed, seen in perpendicular section. *c c*, chordæ tendineæ; *P*, papillary muscle; *s*, surface of cusps lying in contact; *v v*, perpendicular section through the two largest cusps; *w w*, outline of left ventricular wall. The arrows indicate the direction of the blood-pressure.

The arterio-ventricular valves close the openings from the ventricles into the arteries, and as the blood leaves the ventricles they are pushed back into the arteries. When the ventricular systole is completed the elastic recoil of the arteries (presently to be explained) forces the blood both backward and forward, but a portion of the backward-flowing blood enters little dilatations—sinuses of Valsalva—that exist in the arterial walls just behind the segments of the arterio-ventricular valves, and pushes these segments together, thus entirely preventing regurgitation into the ventricles. The arterio-ventricular valves are also called "sigmoid" or "semilunar." They are two in number, the aortic and pulmonic, and they are alike in simplicity; each has three segments nearly equal in size, and of the general shape of isosceles, spherical triangles; they are attached like pockets to the arterial walls; they are without chordæ tendineæ and their free surfaces do not overlap, but, like the auriculo-ventricular segments, are the more firmly pressed in apposition, the stronger the blood-pressure becomes. At the centre of the free margin of each segment is a nodule of fibro-cartilage (corpus Arantii) which is said to prevent leakage at the lines of apposition, but it is not always present; this structure may also be absent in the pulmonic valve (Quain). The lines of contact of the three segments of each valve radiate almost at equal angles from a common centre (Fig. 455). Rarely, there may be four segments instead of three.

FIG. 455.—Diagram of a Closed Semilunar Valve, showing lines of apposition of the three segments.

The ventricular walls during systole crowd toward each other about the attachments of the sigmoid valves, and afford them considerable support (Savory). The aortic valve is surrounded by a layer of circular muscular fibres which have a sphincteric action (Henle). It is said to close .05 to .09 second earlier (Landois, 1876) than the pulmonic valve, owing to the greater blood-pressure in the aorta.

The Cardiac Mechanism as a Whole.—Owing to the aspiration of the chest the auricles during diastole are always under a negative pressure, and in expiration this sinks to −10 mm. Hg. (Fick). Therefore no resistance is offered to the entrance of blood from the large veins while the auricles are relaxed. The venous blood then pours into the auricles and rushes directly through into the ventricles (Burdon-Sanderson), which are also relaxed and probably exert a negative pressure (Goltz, Gaule) or suction force. The auricles become filled sooner than the ventricles, and then contract; they do not force the blood back into the veins because of the venous pressure, and because of the sphincteric muscular fibres in their walls near the auricles, but onward into the ventricles, which offer no resistance. As soon as the ventricles become fully distended they contract and push the blood which they contain against the auriculo-ventricular cusps, forcing them tightly together. Progress of the blood backward into the auricles being thus checked, it forces open the arterio-ventricular valves, and, overcoming the arterial pressure, escapes into the arterial system. Under normal conditions the contraction of the ventricles follows so closely upon that of the auricles (in the horse one-tenth second later, Chauveau), that it appears to the eye as a single rhythmical peristaltic movement (see the section on "Changes in Form"). As soon as the ventricular contraction is ended there follows a period of rest, during which both auricles and ventricles are being immediately refilled preparatory to a repetition of their systole. As the ventricles relax, the mitral and tricuspid valves readily yield to the entering blood. With each contraction the ventricles probably empty themselves completely, and from each one about 180 Gm. of blood (Fick, Volkmann, Vierordt) is forced into the arteries, against an arterial pressure equal to 150 mm. Hg. The arteries, owing to the elasticity of their walls, at first expand on receiving this blood, but immediately thereafter contract, and in so doing force the blood both toward and away from the heart. As soon as the column of blood is forced back toward the heart it shuts down the sigmoid valves, and further progress in that direction is stopped. It must, therefore, advance through the arteries. The dark venous blood with which the right ventricle is filled, passes through the lesser circulation to the lungs, where it becomes aerated, and returns to the left auricle and ventricle as bright red arterial blood.

(For the sounds of the heart, consult article Chest, Physical Examination of).

Cardio-pneumatic Movement.—Because the heart alters in size with each pulsation, it rhythmically compresses the adjoining lung-tissue, and it can be readily demonstrated by the manometric flame that air is thus expelled from the lungs by the heart independently of respiratory movement. The branches of the pulmonary artery, as they are rhythmically expanded by accessions of blood from the right ventricle, are said to compress the bronchi and assist in this process. This "cardio-pneumatic move-

ment," as it is termed, is a factor in changing the air in the lungs of hibernating animals (Landois).

The work of the heart is the effort made by the heart to overcome the resistance of the column of blood contained in the vessels. This work is estimated at 124 foot-tons in twenty-four hours (Haughton). Another calculation makes it equivalent to 204,000 heat-units in twenty-four hours (see article Heat). The work of the left ventricle is about three times as great as that of the right (Volkmann). Recent observations upon the work of the heart were made by W. H. Howell and F. Donaldson, at the Johns Hopkins University, and published in the "Philosoph. Trans. Roy. Soc.," Part I., 1884, pp. 189, 190. The facts determined were obtained with so much originality and accuracy, and are of so much scientific value, that a brief summary of them is quoted below. The experiments were all conducted upon living dogs, whose hearts were isolated and kept beating *in situ* after Martin's method. (See the section on "Experiments with Local Cardiac Stimuli.")

"The most direct factor influencing the quantity of blood sent out from the ventricle, and hence the work done by the ventricle, is the intra-ventricular pressure by which the ventricle is distended during diastole," and since the pressure of the blood in the great veins emptying into the auricle is always at a mean negative quantity (Ludwig, Volkmann, Weyrich), the force distending the ventricle must be purely auricular. This statement is confirmed by Roy's work on the frog's heart (*Journ. Physiol.*, vol. i., p. 485). Diminution of pulse-rate causes an increase in the quantity of blood thrown out from the ventricle at each systole, and consequently an increase in the work done at each systole, and *vice versa*. The number of systoles required for all the blood in the dog's body to pass through the left ventricle is estimated at fifty-four, which at a pulse-rate of 120 would require twenty-seven seconds.

"Variations of arterial pressure from 58 mm. to 147 mm. Hg., have practically no effect whatever on the quantity of blood sent out from the ventricle at each systole," but "the work done by the left ventricle varies directly as the arterial pressure against which it works within the limits named above." Probably each ventricular systole completely empties the ventricular cavity.

"The work done by the left ventricle at each systole increases with the venous pressure, but not proportionally up to the point of maximum work." There was found to be no constant relationship between the weight of the heart and its work.

"The mean ratio of the maximum weight of blood thrown out from the left ventricle at a single systole to the whole body-weight is .00117, or $\frac{1}{860}$ for a mean pulse-rate of 180 per minute." In a dog of 8,125 Gm. weight, the outflow from the aorta, in cubic centimetres, with each systole, was 8.67. In a dog of 9,555 Gm. it was 9.31. When the heart-beats were only 120 per minute (the average normal rate in a dog), the above ratio was found to be $\frac{1}{700}$.

It seems "probable that the left ventricle during life is distended during each diastole to about its maximum capacity." (See also Roy, *loc. cit.*, p. 452.)

THE ARTERIES.—*Functions of the Several Coats.*—The external arterial coat is strong and fibrous, and guards against rupture. When an artery is ligated, this coat remains uninjured, while the others are usually torn (see article Ligatures). The muscular coat alters the calibre of the arteries, and thus regulates the amount of blood sent to any particular organ, and it co-operates with the elastic tissue to adapt the vessels to the varying quantities of blood which they contain. It may assist slightly in propelling the blood-stream. The elastic tissue of the arteries, 1, assists in restoring their proper calibre after it has been increased or diminished; 2, it protects them from the sudden pressure of ventricular systole; 3, it stores up the ventricular force to assist in propelling the blood during diastole; 4, it admits of extensive movements of the arteries of the limbs without rupture; 5, it maintains a sufficient amount of resistance to the onward blood-current to prevent the blood from suddenly running out of the aorta into the rapidly enlarging channel of the collective arteries and arterioles. The relative proportion of elastic tissue diminishes as the arteries become smaller, while the muscular coat is increased. The capacity of the large arteries may be more than quadrupled without passing the limit of their elasticity. In the rabbit the capacity of the pulmonary artery may even be increased twelve times (Roy). The carotid artery of the sheep will withstand fourteen times the normal blood-pressure (Volkmann). The endothelium forms a smooth lining to lessen the friction of the current. The amount of this friction depends upon: 1, the lumen of the vessel; 2, the character and specific gravity of the blood-plasma; 3, the number and character of the corpuscles.

Effect of the Systole.—With each ventricular systole the sudden addition of a quantity of blood to that already contained in the arteries causes: 1, an expansion of the arterial walls propagated away from the heart; 2, a translation of the blood column as a whole, called the "blood current;" 3, a transverse oscillation of the particles of blood, which takes the form of a wave travelling faster than the current (six to twelve metres a second). In a rigid tube this movement could not exist (Power).

The "pulse" is the name of this wave, and its volume and strength depend upon: 1, the force of the systole; 2, the quantity of blood; 3, the degree of elasticity of the arterial walls. Thus the pulse is quite independent of the velocity of the blood-current. It usually disappears before reaching the capillaries, but when they are greatly dilated the arterial pulse may extend to the veins, and a capillary pulse may be seen under the finger-nails (Quincke). (For further consideration of this subject see art. Pulse.)

A vibration of the whole body takes place synchronously with the arterial pulse, which consists of four oscillations to each systole (Gordon, Landois).

The sympathetic nerves, supplying the arteries and arterioles, transmit two kinds of impulses, the action of which is antagonistic, but we are not yet aware of any corresponding changes which take place in their ganglia. One of these impulses—the vaso-constrictor—stimulates the muscular wall of the vessels to contract, thereby diminishing their lumen; the other inhibits (vaso-inhibitory) this action and allows the arteries and arterioles to be passively dilated by the blood to their full limit. These impulses may be centric or peripheric in their origin.

The *vaso-motor centre*, which exercises the principal control, is in the medulla, and extends four or five millimetres above the calamus, to within one millimetre of the corpora quadrigemina (Dittmar, Ludwig).

This centre is in constant action, either automatic or reflex. It may be stimulated by excitation of any sensory nerve (Burdon-Sanderson) and in other ways. Accessory centres, possibly both vaso-constrictor and vaso-inhibitory, are found: 1, in the pons (Brown-Séquard); 2, the cervical part of the cord; and 3, in various ganglia. Impulses from these centres travel down the spinal cord and follow the anterior spinal nerve-roots, after which they reach the prævertebral sympathetic ganglia, whence they are distributed to the vessels. The relation of the vaso-motor centres to the cardio-inhibitory, cardio-accelerator, and respiratory centres, is probably an intimate one. They act normally in unison, and no doubt mutually influence each other. Thus, during digestion the mesenteric arterioles become relaxed and contain so much blood that the arteries would be emptied and the veins engorged; but an accelerating impulse is sent to the heart through the medulla, and this regulates the blood-current. Examples of centric vaso-motor excitation are blushing or pallor, due to mental emotion; the increased vascularity of the cock's comb during cerebral excitement, etc.

Stimulation of a vaso-motor nerve may diminish the constriction of the arterioles which it supplies, and yet produce general contraction of arterioles in other parts. If the nerve be cut the vessels supplied by it dilate. Irritation of almost any nerve may cause arterial reflex dilatation, but arterial constriction is commoner. Something

depends upon the character of the stimulus and length of time through which it is applied. In many instances the constricting impulse seems to wear out in time, or else to be overcome by inhibitory impulses when dilatation follows. Familiar examples of peripheric vaso-motor excitation are the effects of heat and cold upon the cutaneous vessels, the increased vascularity caused by rubbing the conjunctiva, or by irritating any part of the skin. Electrical and chemical stimuli, such as glonoin, amyl nitrite, etc., readily influence the vaso-motor centres and nerves. Diuretics and alterations in the normal ingredients of the urine cause great variations in the calibre of the renal vessels which are very elastic, an important factor in the mechanism of urinary secretion, which secretion depends largely upon the degree of expansion of the renal vessels. (C. S. Roy: "Proceed. Cam. Philosoph. Soc.," May 23, 1881; also Cohnheim: *Virch. Arch.*, vol. xcii., p. 424). The splanchnic is the most powerful vaso-motor nerve. The proper balance of the large number of reflex impulses, of various sorts, constantly passing through the nervous system, is doubtless responsible for the uniformity of the pulse. "Chills" are associated with vaso-motor constriction. A rhythmical expansion and contraction of various blood-vessels, notably those of the kidney and spleen, has been observed and exhibited graphically in a series of curves produced by an apparatus made to enclose these organs and register their alterations in size. These curves differ entirely from sphygmographic and cardiographic tracings (which see) and are known as the "Traube-Hering curves" (see also farther on). The movements are not understood, but are due probably to rhythmical centric vaso-motor stimuli. (See C. S. Roy, *Journ. of Physiol.*, vol. iii., No. 3, p. 203.)

Arterial tonus, tonicity, and resiliency are the names often applied to the vital contractility of the plain muscular fibres of the vessels under nervous or other stimulation, to distinguish it from simple elasticity. After an arteriole has exerted its elasticity to the utmost, vital contractility may diminish its lumen still further, and this effect may even persist many hours after death (Hunter). This force, acting in constant opposition to the distending force of the blood, removes the arteries in many instances from the laws governing simple elastic tubing through which fluid is propelled, and adds to the intricacy of the hydraulics of the circulation. Foster says that tonus is an obscure rhythmic contraction of the arterial wall which is spontaneous and independent of blood-pressure. The word "tonus" is also used to imply the average condition of an artery midway between complete contraction and complete relaxation, in which case the vessel would be said to be of "normal tone." If an artery be compressed its distal portion contracts at first quickly, by virtue of its elasticity (the internal pressure being lessened), and then more slowly when the influence of vital contractility is exerted. The principal use of tonus in arteries and arterioles is to adapt them at all times to the varying volume of blood in circulation; the smaller the artery the greater is this force (see above, the functions of the muscular coat). The maintenance of proper tonus depends upon the balance of various reflexes (see above, vaso-motor irritation).

Arterial tension is the pressure exerted on the blood by the elastic recoil of the arterial walls. It is determined by the relation of the force of the heart and the resistance in advance of the blood-current. When an artery is cut across, its ends retract; this is a measure of the tension of the vessel merely, and not of its elasticity (Savory).

The blood-current initiated by ventricular systole is reinforced by contraction of the elastic arterial walls as soon as they recover from their first sudden distention, which diminishes in proportion to the distance from the heart. The force thus exerted by the arteries depends upon the amount of their muscular and elastic tissue as stated above (see functions of the arterial coats). When the arteries commence to recoil they force the blood both backward and forward, but the backward current flows between the cusps of the aortic valve and the aortic wall (into the sinuses of Valsalva), and forces the cusps together, thereby preventing abruptly any further progress in this direction, and a recoil of the backward-moving column of blood is added to the forward current (see article Sphygmograph).

The velocity of the arterial current is diminished by: 1. The increasing diameter of its channel, for the collective area of the cross-sections of the branches of an artery is always greater than the area of the section of the artery itself (with the exception of the aorta, common iliacs, and sacral) (Quain). The current is therefore swifter in the arteries than in the arterioles. 2. The friction offered by the increased area of the walls of the branching vessels (blood has greater cohesion than water). 3. The little whirls formed at the bifurcations and bends in the vessels. 4. Very distensible arterial walls, for the more rigid the tube the swifter the current. The yielding of an elastic tube diminishes the velocity of the current, but increases the amount of fluid discharged (Robertson, Marey).

The velocity varies in different animals, as well as in the same animal at different times. It is less at night than in the day. In the horse, in the carotid, the velocity is 300 mm. a second (Vierordt, Volkmann); 520 to 120 mm. (Chauveau); in the maxillary, 165 mm. a second; in the metatarsal, 56 mm. (Volkmann). The whole course of the circulation is traversed in the horse in from thirty to fifty seconds; in the rabbit in seven seconds; in the dog, 18.03 seconds; in man, twenty-three seconds (Vierordt). The speed of the current in the largest arteries is not uniform, for they are too near the heart for their blood to be as much influenced by the elastic recoil as in the case of distant vessels, whose current is regulated by the recoil of the long arterial walls behind the advancing blood column; the tendency of elastic tubes being to convert intermittent into continuous force. Thus, in the carotid the speed varies from less than 150 mm. a second during diastole, to more than 500 mm. a second during systole (Chauveau). In arterioles the speed is 300 mm. a second (Volkmann).

The blood-pressure is the pressure exerted by the blood upon its vessels, owing to the momentum which it receives from the cardiac systole and from the elastic arterial recoil. It varies naturally in the various parts of the body, and the local variations are frequent and may include large areas; but it should be especially borne in mind that extensive general alterations in the blood-pressure of the whole body cannot be made permanent even by transfusion (Cohnheim), because the action of the vessels already explained tends constantly to regulate the distribution of the blood, and, moreover, the kidneys assist by affording a ready outflow for superfluous fluid from the blood, and transfusion may be carried to such an extent as to cause death without previously permanently increasing the blood-pressure to any great extent. The pressure is normally greatest in the left ventricle and aorta, and rapidly diminishes toward the capillaries, while in the great veins it becomes negative.

The Manometer (Poissenille-Hales, Ludwig, and others) is an apparatus for measuring blood-pressure. The simplest form at present in use consists essentially of an upright U-shaped glass tube partially filled with mercury; one arm of it, containing a little solution of bicarbonate of potassium, or similar salt, to prevent coagulation, is connected with a living artery, part of the blood from which flows into this arm and pushes the mercurial column before it into the other arm. The movement of the mercury is readily measured graphically by a rod which floats upon the mercury and joins a lever and pen outside of the tube. The pen traces any oscillations of the mercury caused by variations in blood-pressure upon a surface of paper kept in motion by clock-work. This arrangement is the kymographion of Ludwig and Volkmann. A double series of oscillations will be thus observed, which are called the "Traube-Hering curves." The first are produced by ventricular systole, and a column of mercury may thus be made to rise and fall twelve to fifteen millimetres. The second are of greater amplitude and longer interval, and are synchronous with the respiratory movements. If respiration be quiet, the curve is slight, but if active, it may vary thirty millimetres

in the calf (Curtis). (See below, influence of respiration on circulation.) The "mean blood-pressure" of any vessel is determined by the average between the highest and lowest of its curves thus obtained.

Arterial blood-pressure falls with: 1, each diastole; 2, aortic valvular insufficiency, which allows the blood to flow backward into the ventricle; 3, loss of tonus in the larger arteries, which admits of their greater distention; 4, loss of tonus in the arterioles, whereby they offer less resistance to the passage of the blood; warmth applied to the surface of the body relaxes the arterioles and permits the larger arteries to empty their blood into them more readily, causing a fall in the pressure of the larger arteries; 5, inspiration; 6, extensive hæmorrhage; 7, stimulation of the nervus depressorius (see above, cardiac nerves, p. 564); 8, division of any vaso-motor constrictor, *e.g.*, the splanchnic. Arterial depressor nerve-fibres are said to occur in the vagus itself, in the cervical sympathetic, and superior laryngeal nerves (Aubert, Röver).

Mean arterial pressure is lower in small than in large animals, and lower in very young and very old animals than in those of middle age; but in a child the pulmonary pressure is relatively higher than in the adult (Beneke). The pulmonic vessels are very distensible, and the force which maintains their tone is slight, for the lesser circulation is less dependent on the nervous system than the greater; so, if one branch of the pulmonary artery is plugged, aortic pressure is not necessarily altered (Lichtheim). Diminished atmospheric pressure lowers arterial pressure, as is seen in cupping; this effect, however, like many of the circumstances enumerated above, may be very transient, owing to the tendency of the vessels in different parts of the body to maintain an average pressure which shall be very constant; thus cupping removes a certain amount of resistance from the smallest vessels, and additional blood at once enters them; this blood, however, increases the pressure upon their walls, and consequently their mean pressure may have been little if any disturbed. So it is that many causes, which would of themselves tend to lower local pressure, are met by simultaneous changes in other vessels which maintain an unvarying pressure, although the quantity of blood may vary greatly. Were it not for the resistance of the arterioles, and for friction, the heart could never overfill the arteries at each systole, and the pressure in the great veins and arteries would tend to become equal. All circumstances that decrease the difference between arterial and venous pressures increase the venous pressure, and *vice versa* (Landois). When an artery is cut across, the blood issues in a continuous stream with rhythmical exacerbations of velocity. Following each ventricular systole, the blood spurts out with great force, but during diastole the flow is kept up with less violence by the elastic recoil of the arteries. In general, two and a half times more blood issues from a cut artery than from a cut vein of the same calibre. The total amount of blood in the body is estimated at one-thirteenth of its weight. If the loss of blood equals two or three per cent. of the body-weight, the heart-power fails (Power). A slight loss causes less oxygen to be conveyed to the vaso-motor centres, and a contracting impulse is probably sent thence to the arterioles which maintains the normal tonus, although the loss of blood itself tends to lessen tension.

Influence of Respiration on the Circulation.—The heart and large vessels are exposed to an atmospheric pressure which is minus the influence of the elastic traction of the chest. When the chest expands in inspiration, the right auricle is relieved of a certain amount of extra-cardiac pressure, and venous blood is sucked into it; simultaneously the pressure upon the arteries in the chest is lessened and their blood flows more slowly. Conversely, in expiration the diminishing capacity of the chest increases the pressure upon its contained organs, and the venous flow into the heart is retarded, while the arterial blood is favored in its outward flow (Barry). Both of these factors tend to raise arterial tension. These effects are modified by the simultaneous influence brought to bear on the vaso-motor centres by blood of varying degrees of oxidation. There is thus a double aspiration carried on by the chest and by the heart itself. Artificial respiration slows the blood-current, and may interrupt it (Dogiel), until dyspnoic stimulation of the respiratory centre results (Heidenhain). Expiration into rarefied air increases mean blood-pressure and inspiration of compressed air diminishes it (Zuntz). Opening the chest-wall of course annuls its aspiration.

THE CAPILLARIES.—The capillaries are protoplasm in the form of tubes (Stricker), and they possess contractile power like the arterioles (v. Bezold, Roy), though in less degree, and they are often surrounded by elastic tissues which may favor their contractility. They may be themselves elastic.

The velocity of the capillary current is several hundred times slower than the arterial current, because the velocity of a current in a tube is inversely as its lumen. In the horse, if fifty seconds are allowed for the entire circulation cycle, one second is spent in passing through the capillaries. The average speed of capillary circulation in man is six to nine millimetres a second (Vierordt), but in pulmonary capillaries the blood-flow is five times as rapid as in the capillaries of the skin. In the human lung the blood passes from artery to vein in one second (Draper). The average length of the capillaries is four millimetres (Weber), and their united calibre is estimated at seven hundred times that of the aorta (Vierordt); but as they are far shorter than the arteries, they probably do not contain very much more blood (Dalton). When capillaries are cut the blood oozes from them and collects in drops upon the surface (Malpighi, 1661; Loevenhock, 1668). Their walls probably permit of free osmosis in both directions (see art. Absorption).

The red blood-disks roll along in the axillary current, occupying the greater part—three-fifths—of the centre of the capillary tubes (Fig. 456); the peripheral zone is called "Poissenille's space." Their long axes are mostly parallel with the direction of the current, and where a capillary bifurcates into smaller vessels a red corpuscle not infrequently becomes caught upon the projecting dividing wall (Fig. 456, *C C C*), and balances there until a fellow-disk or the force of the current twists it off; thus the importance of a proper relation between the specific gravity of the plasma and the corpuscles is obvious. Occasionally, upon entering a minute capillary, several corpuscles become jammed and obstruct the circulation until pushed along by accumulating pressure from be-

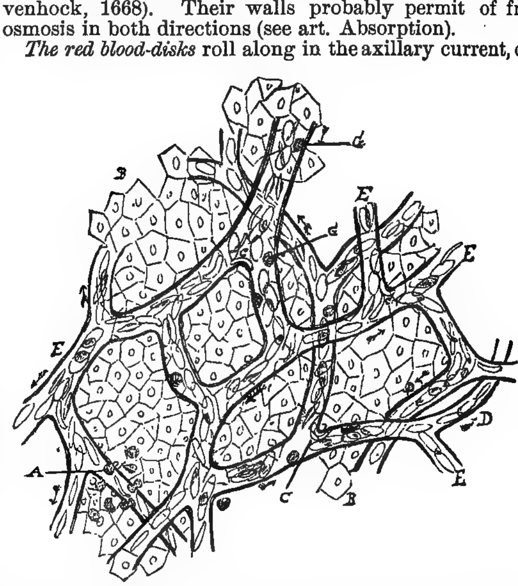

FIG. 456.—Diagram of the Circulation in the Web of a Frog's Foot. *A*, white corpuscles passing through the capillary walls; *B B*, epithelial cells of surrounding skin; *C C C*, red corpuscles bent and caught at the bifurcation of a capillary; *D D*, blood-current flowing in apparently opposite directions; *E E E*, capillary vessels containing red and white corpuscles; *G G*, white corpuscles loitering along the capillary wall.

hind; the current, therefore, becomes quite irregular in velocity in the different capillaries, and at times in individual capillaries it ceases for an instant, but the average speed in a large number of capillaries is fairly uniform. It sometimes appears to flow in two opposite directions, owing to the crossing of the capillaries (Fig. 456, *D D*), but the movement is uniformly from the arterioles to the veins.

The white corpuscles, being lighter than the red, are crowded to the capillary wall, chiefly to its upper side, in Poissenille's space (Hamilton), and because they are less smooth and more viscid they move ten or twelve times more slowly than the red disks (Weber), and often halt for some time (Fig. 456, G G). A heavy powder, or heavy pus-corpuscles injected into the circulation will drive the red disks to the wall.

Diapedesis (Addison, Waller, Cohnheim) is the phenomenon, sometimes witnessed in health, but better in inflammation, of the passage of the white corpuscles through a capillary wall into the surrounding tissue. Just how this takes place is disputed. It has been said (1) that the corpuscle pushes a projecting arm through one of the spaces called "stomata" in the capillary wall (Arnold), or (2) through the cement substance of the adjoining margins of the cells which form the walls of a capillary, or (3) that it goes through the cells at any point, leaving no perforation, and then it gradually flows into this arm by an amœboid movement (Fig. 456, A). Whether this movement be purely automatic, or whether it be a sort of filtration of the colloid mass of the white corpuscles under blood-pressure (Herring) is undetermined. When half-way through the wall, it has a dumb-bell shape. The red corpuscles and other ingredients of the blood may pass through in inflammation, and the latter also in health by osmosis. These various capillary phenomena are observed in a frog's tongue, web, or mesentery, or in a bat's wing, rabbit's mesentery, etc.; and they have been studied in the human lip (Hüter).

Capillary attraction is certainly a factor in aiding the blood-flow from arterioles to veins, but very little importance is attached to it by most physiologists of the present time, who claim that the vis-a-tergo, or energy of the heart, is sufficient to propel the blood through the entire circulation. There is much to be said upon both sides. The chemical changes which take place in each tissue-cell as it draws its nutriment from the blood-plasma, its oxygen from the red blood-disks, etc., necessarily implies molecular motion. Nutritious molecules, or atoms, enter each living cell, and displace those substances which are no longer of use. The aggregate of all this movement is a very considerable force. If two fluids of different affinity are confined within a capillary tube, the fluid having the greater affinity for the walls of the tube will drive the other forward. Arterial blood has great affinity for the tissues, venous blood has little or none (Draper). Moreover; after removal of the heart in some animals, the arteries have been found empty, and capillary circulation has continued for a while—even, it is said, after the force of elastic recoil of the arteries has been expended. It has also been observed in one acardiac child of a twin monster. Movements of the sap in plants are entirely dependent upon capillary and cellular physical and chemical forces. Drugs injected into the blood alter the rapidity of the capillary circulation; $NaCl$ and Na_2SO_4 diminish its speed, while KI and KNO_3 increase it.

On the other hand, the force of each systole—the work of the heart—is estimated at one-tenth greater than the arterial resistance offered, and an equal force of mercurial pressure alone in the cadaver will drive the blood around the entire circulation.

The capillary blood-pressure is not easily estimated. In the hand it varies between twenty-four and fifty-four millimetres of mercury (Kries). Substances in solution enter both the capillaries and small veins by absorption, against the blood-pressure, by a mechanism which is not clearly understood, but which is no doubt controlled by nervous mechanism; for, when a sensory nerve is excited, venous absorption is increased (Goltz).

THE VEINS.—The veins have a greater lumen than the arteries, both collectively and as compared with corresponding individual arteries, and their walls are thinner, but stronger and quite extensile, and they contain valves. The jugular vein supports a column of water 148 feet high, and the portal vein a pressure of six atmospheres. The aorta of a sheep ruptures under a pressure of 72 kilogrammes, while the vena cava supports 80 kilogrammes (Davis). (See article Blood-vessels.) They may be drawn out for fifty per cent. of additional length without passing the limit of their elasticity. They diminish in collective area as they approach the heart, and their blood moves with increasing speed, the channel being narrower and the walls presenting less surface for friction.

The venous blood is propelled by, 1, whatever remains of the systolic force of the heart and of the pressure of the arteries (Ozanan) after the capillaries have been traversed; 2, whatever capillary force exists; 3, the suction power of the right auricle and right ventricle (?), which must be very slight; 4, the negative pressure exerted by the chest upon the great veins contained within; of course, this ceases when the chest-wall is opened and the lungs collapse, and yet the circulation continues for a while under these conditions; 5, muscular action, which compresses the yielding venous walls and drives the blood forward in those veins in which valves prevent its backward course. The pressure of the abdominal viscera during expiration against the large abdominal veins may aid their blood-flow.

FIG. 457. — The Valves of a Vein. Closed at *A* by backward pressure, which distends the wall of the vein. The vein is laid open at *B*, to show the attachment of the two segments.

The valves of the veins (Fabricius ab Aquapendente), as a rule, occur in the longest veins, and they are formed of semilunar folds of the tunica intima of the vein (Fig. 457, B). In man they have usually two segments, in the horse sometimes three, in some animals but one (Quain). The veins of most reptiles and fish (which keep largely a horizontal position) have no valves. Birds, and some reptiles, have valves in the veins near the auricles, but in mammals these veins have no valves, and their circular muscular fibres prevent reflux during auricular contraction by a sphincteric action (see above). If pressure be made upon one of the prominent veins of the arm or forearm, the part of the vein nearest the heart will become empty, while the distal portion continues to distend, owing to the momentum of the blood-current, until it becomes so full that a backward pressure results, which causes the nearest valve to close. The blood crowding back against the valve causes the walls of the vein to bulge out just above its insertion, which gives a knotty appearance easily seen through the integument (Fig. 457, A).

The velocity of the venous current is one-half to three-fourths less in the large veins than the current in corresponding arteries; it is greater than the velocity of the capillary current, and diminishes toward the heart. In the jugular vein of the dog it is 2.25 millimetres a second (Volkmann); of the horse, 100 millimetres a second. If a vein be cut across, a continuous and regular stream issues from its distal extremity, which has less force than the arterial stream, whereas the proximal end is at once closed by atmospheric pressure, except where the vein is diseased, or held open by adhesions, or by peculiar anatomical structure or relations, as in the liver or neck. This condition admits of air being sucked into the veins sometimes during operations (Valsalva). Air thus entering passes to the right side of the heart, where it is churned into a froth that enters the pulmonic vessels, and forms emboli which may be a cause of death.

The vital contractility of veins is less than that of the arteries, generally speaking, but in a bat's wing a venous pulsation may be observed occurring about ten times a minute and independent of the heart-beats (Jones, Schiff), and there is a pulsation in the vena cava of the frog (see

above). If obstruction exist to the circulation in the lungs, the right ventricle may not be able to empty itself completely into the pulmonary artery, hence it becomes overfilled, and it is said that the tricuspid valve does not then close tightly, but admits of regurgitation into the auricle, which in turn may dam up the venous current and be a cause of venous pulsation, especially in the jugulars. This action of the tricuspid valve (which is still disputed by some) is spoken of as its "safety-valve action" (Hunter, Wilkinson, King).

The blood-pressure in the several veins varies greatly and diminishes toward the heart, and change of position seems to alter venous pressure more than arterial; but the great disadvantage of gravity under which the venous blood has been said to labor, as compared with arterial, does not exist, because the arterial column will support a column of fluid equal to its own height if there is no marked difference in its specific gravity. The vessels, however, which are lowest in the erect body support the weight of the fluid above them (excepting those veins which are able to divide this fluid by valves), and therefore œdema may be favored in the legs and feet in diseased conditions, which may disappear when the patient lies down (see art. Anasarca). The brachial current supports a column of mercury 9 mm. high; the crural, 11.4 mm.; but the pressure in all the large veins at the heart is always negative (Ludwig, Volkmann, Weyrich), and varies from −2 mm. to −3 mm. Hg. with the heart-beats, and from −5 mm. to −8 mm. with the respiratory movements, this negative pressure being increased by inspiration. The mean negative pressure is by some observers estimated at −10 mm., but probably the variation between highest and lowest negative pressure does not exceed 1 mm. in ordinary respiration. (For venous murmurs and venous valvular sounds, see art. Chest, Physical Examination of.)

The amount of blood distributed by the circulation to the various organs depends upon their activity, thus the blood of certain glands may be increased thirty or forty per cent. during their most active period. One-fourth part of all the blood in a rabbit is found circulating normally in each of the following divisions (Ranke): 1, passive muscles; 2, liver; 3, circulatory organs; 4, all other parts together.

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William Gilman Thompson.

BLOOD, PATHOLOGY OF THE. In order to understand the changes which occur in the blood under pathological conditions, a preliminary knowledge of the structure and physiology of this tissue is necessary. For this the reader is referred to the article on the Physiology of the Blood.

The pathological changes in the blood have to do with variation in the amount of blood; increase or diminution in the number of its morphological elements; alterations in the substances held in solution; presence of abnormal elements.

An increase in the amount of blood, as a whole, its composition remaining the same, is a true plethora. Such a condition is readily produced artificially in animals by injecting into a vein defibrinated blood of an animal of the same species. By this means Worm Mueller found that a quantity equal to from one-half to two-thirds of the amount of blood originally in the animal could be injected without injury, though if the amount injected equalled one to one and a half times the original volume of blood, death always followed. This artificial plethora is only a temporary condition, there being a rapid return to the normal amount of blood, brought about, first by an excretion of the watery elements through the kidneys, followed later by an actual destruction of the excess of red blood-corpuscles.

That a plethora vera exists in man has not yet been proven. Against the probability of its occurrence is that regulatory power, just mentioned, which tends to dispose of any blood in excess of the normal amount. Moreover, the ingestion of a superabundance of food does not tend to increase the amount of the blood, nor the number of corpuscles, beyond what is considered as a normal standard; on the contrary, a greater formation of fat-tissue is the result observed.

An increase in the amount of the blood from an increase in the watery element is of very common occurrence as a transitory condition, and occasionally as a permanent one. Thus, after drinking much fluid, a rapid absorption of it takes place into the blood-current, increasing the amount of the blood. The excess is, however, rapidly gotten rid of by the kidneys or skin.

In some pathological conditions, especially in chronic nephritis, in which the secretion of the watery element is interfered with, its retention in the blood may become permanent. To this condition the name of hydræmic plethora has been given (see Anæmia, Hydræmia, etc.)

A diminution in the total amount of blood, oligæmia, occurs after hæmorrhage; but the diminution in the amount as a whole is only transitory, for, to make up for the quantity lost, sufficient fluid is absorbed from the lymphatics.

A diminution in the amount of blood also occurs from loss of the watery element. This is seen in men or animals deprived of water, also in diarrhœa, but most typically in cholera, in which disease the blood frequently becomes of a tarry consistency from the loss of serum, owing to the enormous secretion in the intestinal tract.

Thus far the changes spoken of have had to do with an absolute increase or diminution in the total amount of blood; next will be considered the relative changes, the total amount remaining nearly normal.

A relative increase in the watery element of the blood occurs as a result of diminution of the solid constituents. Thus, after a hæmorrhage, as mentioned above, a diminution of the blood as a whole occurs. The quantity lost is quickly replaced by absorption of lymph, but the corpuscles are only regenerated very slowly, hence for some time the blood will be more watery than usual. To this condition the name of hydræmia is applied. (The regeneration of the blood after hæmorrhage will be fully described in the article Hæmorrhage.)

The watery element is also relatively increased in cases in which the red corpuscles are diminished from causes to be described later.

A permanent hydræmia is observed in conditions leading to a diminution in the amount of albumen, this forming one of the most important soluble constituents of the plasma. This loss may be dependent either upon diseases like chronic diarrhœa or suppurative processes, or else upon the direct passage of the albumen from the blood into the urine, as in nephritis. An insufficient supply of food, starvation, brings about a similar condition of the blood. The term hypalbuminosis is also applied to designate the diminished amount of albumen.

A hyperalbuminosis, or increase in the amount of albumen, occurs either as a relative increase, as in the abundant loss of the watery element in cholera, or as an absolute increase, in cases in which much food and but little exercise are taken.

Of importance are the changes in the morphological elements, the corpuscles. An absolute increase in the

number of red blood-corpuscles probably does not occur, or if at all, is only transitory. A diminution in the number of red corpuscles, anæmia, oligocythæmia, is of very common occurrence. Anæmia exists after a hæmorrhage, the extent, of course, being dependent upon the amount of blood lost. In connection with many chronic or wasting diseases, a marked diminution in the number of red corpuscles occurs. To this form the name of consecutive anæmia is applied. By the term simple anæmia is meant a diminution in the red corpuscles, not dependent upon recognizable disease of any of the organs, and which is readily amenable to suitable treatment. Under this head comes a form of anæmia known as chlorosis, occurring mostly in girls soon after the age of puberty (see Chlorosis).

Lastly is to be mentioned a form of anæmia known as essential, idiopathic, or progressive pernicious anæmia. The pathology of this is very obscure, but, at present, under this head are to be classed those cases of anæmia in which no primary disease of any organ is discoverable; in which the diminution in the number of red blood-corpuscles is progressive and extreme, often reaching 500,000 per cubic millimetre; and in which treatment is of no avail.

The most striking factor in this disease is the marked pallor and exhaustion, with a well-retained or abundantly increased panniculus adiposus. So far as the present knowledge goes, one cannot say whether the diminution in the number of red corpuscles is a primary or a secondary condition. The only change thus far discovered which may be regarded as in any way the cause of this diminution, is the transformation of the marrow of the bones from a yellow to a red. But as this same condition of the marrow, to a less degree, has been found in cases of consecutive anæmia, the probability of its being simply a secondary change is much increased. One series of pathological changes which may be considered to be secondary to the anæmia is the fatty degeneration, often extensive, of the muscular substance of the heart and of the cells of the kidney and liver, due to diminished supply of oxygen. Nucleated red blood-corpuscles are frequently found in the blood, as well as in the bone-marrow. Their presence is not indicative of this special disease, as they are found in other forms of anæmia and in leucæmia. Their occurrence is associated either with a rapid regeneration of red corpuscles, or else with a prevention of the complete transformation of white into red corpuscles.

In addition to the decrease in the number of red corpuscles in anæmia, is to be mentioned also the diminution in the amount of its important constituent, hæmoglobin—oligochromæmia; there being a relative as well as an absolute loss of hæmoglobin; that is to say, the hæmoglobin is lessened because the red corpuscles are diminished; it is further lessened because each remaining corpuscle contains less than its normal amount of this substance.

In cases of anæmia, the diminution in the number of red corpuscles is determined by counting; the best apparatus for this purpose being that invented by Hayem, modified by Gowers, Abbe, and Thoma, and made by Zeiss, of Jena. The amount of hæmoglobin can be determined by Hayem's hæmochromometer.

Changes in the size and form of the red blood-corpuscles occur. They may be very large, so-called macrocytes, seen in anæmia and in lead-poisoning. Their origin is unknown. Corpuscles smaller than usual, microcytes, are seen under various conditions, especially in pernicious anæmia. Corpuscles with irregular shapes, often with pointed processes, poikolocytes, are met with in pernicious anæmia. In general, it may be said that extreme caution should be used in inferring that variations in the size or shape of red corpuscles are due to pathological processes, inasmuch as any variation in the density of the medium in which they are examined from that of blood serum, will produce marked artificial changes.

An increase in the number of the white corpuscles, if temporary, as in many acute diseases and in suppurative processes, is termed leucocytosis; if permanent, is termed leucæmia, or leucocythæmia, the former term being the better one. Leucæmia is always associated with a diminution in the number of red corpuscles.

The usual relation of white to red is about one to three hundred, although there is considerable variation within normal limits. In leucæmia, the ratio may be from one to twenty, to one to one. With the increase in the number of white corpuscles there is always an hyperplasia of the lymph-apparatus of the body, either spleen, lymph-glands, or marrow of the bones, singly or combined. According as one or the other of these predominates, one speaks of it as a splenic, lymphatic, or myelogenous form of leucæmia. This increase in the size of the lymphatic organs undoubtedly plays an important rôle in the formation of the increased number of white corpuscles, and it is also probable that the increase is in part due to many of the white corpuscles not undergoing the ordinary transformation into red corpuscles; but there must also be another factor not yet understood, for in the disease known as pseudo-leucæmia, or lympho-sarcoma, one sees changes in the above-mentioned organs which are indistinguishable, by any means now used, from those in true leucæmia, and yet there is no increase in the number of white corpuscles, though the red are much diminished. The cause of leucæmia is wholly unknown.

The appearance of the blood in gross, in advanced cases, is very striking: it is so pale as often to give the impression that the vessels are filled with pus. The pale, clay-colored clots in the vessels are often covered with a creamy, pus-like layer. In the blood are frequently found large numbers of octahedral, colorless crystals, probably albuminoid in composition, called, after their discoverer, Charcot's crystals. (For the clinical account of this disease see article Leucocythæmia.)

The coagulation of the blood, due to the formation of fibrin, represents a very important process.

According to the views of Alexander Schmidt, which have now borne ten years' criticism without having been overthrown, fibrin does not exist preformed in the blood and held in solution, as formerly supposed, but owes its origin to the interaction of two substances, fibrinogen and fibrinoplastin, in the presence of a third material, a ferment. Fibrinogen is held in solution in the plasma, while fibrinoplastin, or paraglobulin, as it is also called, together with the ferment, are held in the white corpuscles. Further, it is only upon the death of the white corpuscles that the fibrinoplastin and ferment are set free, and the former, by acting upon the fibrinogen in the presence of the latter, yields fibrin.

In blood outside the body, or in the tissues outside the vessels, coagulation quickly occurs. Within the vessel, during life, coagulation is prevented by two factors, intactness of the endothelial lining, and motion of the blood; of these, probably the former is the more important. Destroy the endothelium, or retard or stop the motion, then coagulation occurs, probably as a result of the death of the white corpuscles, and the succeeding changes mentioned above. Such a coagulation of the blood in the vessels during life is termed thrombosis, the clot a thrombus. If the blood is brought to a complete stand-still, as by tying a vessel, coagulation occurs up to the point of the giving off of the first branch, the thrombus thus formed being of a red color, as it contains all the constituents of the blood,—the red or obliterating thrombus. Where there is a loss of the lining endothelium the white corpuscles adhere to the eroded spot, and by their death produce fibrin,—the pale or parietal thrombus.

Thrombi do not remain as masses of fibrin, enclosing or not red corpuscles, as the case may be, but are either absorbed as the result of a new-formed connective-tissue developing from the wall upon which they lie—the so-called organization of the thrombus; or, where insufficient reaction occurs in the wall to form such a tissue, fatty degeneration takes place, beginning in the centre of the thrombus and forming a pap-like mass. If septic micro-organisms be present, a form of softening known as septic or putrid softening occurs. This latter is seen in thrombi in the veins of operation-wounds or in the venous sinuses of the uterus, where a diphtheritic or gan-

grenous inflammation of the wounded surface is present.

At autopsies the arteries are usually found to contain no blood, while the capillaries and veins are more or less full. In the capillaries coagulation rarely occurs post-mortem, but in the veins it is the rule. If the individual has died of an acute inflammatory disease, especially such as involve the serous membranes, one finds abundant firm, pale coagula, made up almost wholly of fibrin. In certain cases the blood is found to be fluid throughout the body; this is most commonly seen in death from suffocation, *i.e.*, insufficient oxygenation of the blood. In septicæmia a like fluid condition of the blood is observed.

The normal color of the blood is dependent upon the mixture of its constituents, the prevailing red color being due to the hæmoglobin contained in the red corpuscles.

Variations in the color are dependent either upon chemical changes in the hæmoglobin, or upon increase or diminution of the elements, or upon admixture with foreign substances.

Hæmoglobin has a strong tendency to unite with various gases. Combined with oxygen, it forms oxyhæmoglobin, and gives the bright red color of arterial blood; with a small amount of carbon dioxide, the dark red color of venous blood; with an excess of carbon dioxide, as seen in death from suffocation, a nearly black color. Hæmoglobin combined with carbon oxide, as seen in cases of death from the inhalation of the fumes of burning charcoal and some kinds of illuminating gas, gives to the blood a bright cherry-red color. In the two latter conditions mentioned there is also an absence of coagulation post-mortem.

After poisoning by the nitrites, as nitrite of amyl, the blood is said to be chocolate-colored.

Diminution in the amount of hæmoglobin, associated or not with diminished number of red corpuscles, produces a pale red blood.

The peculiar color of the blood associated with an increase in the number of the white corpuscles, has been described above in connection with leucæmia.

The hæmoglobin is sometimes dissolved out of the red corpuscles, probably as a result of the destruction of the latter, and is then held in solution in the serum. This condition is known as hæmoglobinæmia. It has been observed after severe burns; after the transfusion of foreign blood in men and animals; after poisoning by chlorate of potash, arseniuretted hydrogen, nitrobenzole, and pyrogallic, carbolic, and sulphuric acids; in septicæmia; as a disease in man in which, after exposure to cold, an abundant flow of nearly black urine occurs—hæmoglobinuria. This contains no corpuscles, but abundant hæmoglobin in solution, and it is fair to assume that the hæmoglobin is set free in the circulating blood.

The color of the blood in hæmoglobinæmia is that known as "lake."

Various abnormal constituents may be found in the blood. Among these are small particles of black pigment—melanæmia. This condition is seen in severe cases of intermittent fever, the particles representing the altered blood-pigment set free by the death of the red corpuscles. Post-mortem the liver and spleen are found to contain a large amount of this melanin.

Sugar is present normally in the blood in very small quantity, but in diabetes it is greatly increased—mellitæmia. Occasionally muscle-sugar—inosit—is found in the blood.

A substance known as aceton, a derivative of acetic acid, is frequently present in the blood in the later stages of diabetes—acetonæmia. It is now generally held that diabetic coma is due to the action of aceton upon the central nervous system.

Bile is frequently present in the blood, any obstruction to its flow into the intestine leading to a backing up in the liver and to its absorption by the blood—cholæmia. The biliary coloring matter stains various tissues of the body, producing icterus. Bile in the blood is injurious, owing to its power of dissolving red blood-corpuscles and setting free the hæmoglobin.

Probably a similar coloring may occur as a result of the formation of pigment directly from the blood, viz., hæmatoidin, bilirubin. If the tissues are secondarily stained by these pigments the term hæmatogenous jaundice is applied.

After extensive hæmorrhages into the tissues or preformed spaces of the body, there may be absorbed from the effused blood hæmoglobin in the form of disks, or hæmatoidin in the form of rhombic crystals, or bilirubin in the form of acicular crystals, which find their way into the blood-current probably through the agency of the lymphatics.

When the materials ordinarily excreted by the kidneys are retained in the blood, as a result of disease of this organ, the condition known as uræmia is said to be present.

In cases of septic inflammatory processes of the mucous membrane of the bladder, the urea held in solution in the urine contained in the bladder may be decomposed, giving rise to the formation of ammonia. This gas may, in turn, be reabsorbed by the circulating blood, producing the condition known as ammonæmia.

The term lithæmia has been much used by clinicians, but whether lithates or urates are actually present in the blood in excess has not been satisfactorily proven.

Fat may be present in a molecular form, as after a meal containing abundant fat—chylæmia. Fat may be present in the form of larger drops—lipæmia—as is seen in diabetes and after extensive crushing of fat-tissue or bone-marrow, the fat set free being absorbed by the veins.

Air is found in the blood, gaining entrance through wounds in the veins of the neck or through open uterine sinuses, there being a negative pressure in the former during inspiration and in the latter in certain positions of the pregnant or recently delivered uterus. In such cases the air may be found widely distributed in the blood-vessels, but is most abundant in the right side of the heart and in the lungs.

Fatty-degenerated endothelial cells, as well as cells from new-growths extending into blood-vessels, are occasionally found in the blood.

Bits of detached valve of the heart, portions of thrombi (*i.e.*, emboli), calcareous plates from the intima of the aorta are also found in the blood.

Of the animal parasites found in the blood are to be mentioned the filaria sanguinis hominis, in the blood of those suffering from chyluria. This is a microscopic worm, occurring mostly in warm countries, *e.g.*, in India, and found in the blood and urine of patients during the attacks of chyluria and hæmaturia.

The distomum hæmatobium, discovered by Bilharz in Egypt, is found in the portal vein in certain cases of tropical dysentery. The eggs of this parasite collect in the mucous membrane of the ureters, bladder, and large intestine, leading to inflammation associated with hæmorrhages and dysentery.

Trichinæ and the embryos of cysticerci and echinococci are found, rarely, in the blood.

The relation of the lower forms of vegetable life, the fungi, to the blood is likely in the future to be one of great importance. Unfortunately, at the present time very little definite is known in regard to this relation. It has not as yet been definitely determined whether micro-organisms are present in the blood in health.

In regard to the higher class of the fungi, the mould fungi, no observation of their presence in the blood of man is known to the writer.

Of the lower class of the fungi, the so-called bacteria, their presence in the blood has been determined with certainty in but two diseases in man, namely, relapsing fever and anthrax, or splenic fever. In the former, at the height of the exacerbation the spirillum discovered by Obermeier is found in abundance. In anthrax, the characteristic bacillus anthracis can readily be made out in the blood.

Certain authors claim to have discovered the so-called bacillus tuberculosis in the blood; but this, together with the statements of the finding of other micro-organisms, needs further substantiation.

The relation of micro-organisms to the blood as ferments; the question of the absorption by the blood of the ferment-products of such organisms, as upon a wounded or eroded surface; the question of the absorption from the intestinal tract, by the blood, of substances produced by abnormal fermentation in that canal, are of the highest degree of interest. But the imperfect and chaotic state of the knowledge of these important factors prevents a detailed consideration of them in an article of this character. *W. W. Gannett.*

BLOOD-LETTING (Synon.: Bleeding; Fr., *La Saignée;* Ger., *Der Aderlass*); the abstraction of blood from the body for therapeutic purposes. This may be accomplished in either of two ways, called *local* and *general* blood-letting. By general bleeding is understood the abstraction of blood rapidly and in quantity from one of the larger vessels. Local bleeding consists in the gradual withdrawal of blood from the capillaries of a part by means of leeches, scarification, or wet cups. General bleeding from a vein is called venesection or phlebotomy. It may be performed upon any of the superficial veins of the body, but the one most commonly selected for the purpose is the median cephalic, or the median basilic, lying over the flexure of the elbow (see Fig. 458). A fillet is tied tightly around the arm immediately above the elbow (at A), so as to render the veins turgid and bring them prominently into view. Then, a graduated vessel for receiving and measuring the blood being at hand, the skin is stretched slightly over the part and an incision is made into and nearly through the vein, obliquely to its axis. Care should be taken not to disturb the relative positions of the skin and vein, otherwise when the hand is removed the skin will slide over the deeper parts, forming a valvular opening, and the blood will escape into the tissues instead of externally. The incision should not be made too deep, because of the danger of wounding the brachial artery beneath, thus giving rise to a varicose aneurism or an aneurismal varix. After a sufficient quantity of blood has been withdrawn the fillet is removed and a compress applied over the wound. A vein in the hand or the foot may be opened in the same way. Phlebotomy from the external jugular vein, which was formerly practised to a considerable extent, has been nearly abandoned, and rightly, because of the inconvenient location of the vessel, and also because of the danger of air entering the vein.

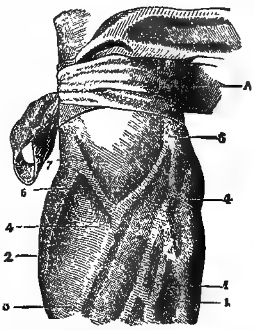


FIG. 458.—The Superficial Veins of the Forearm. 1, Cubital; 2, radial; 3, median; 4, median-basilic; 5, median-cephalic; 6, basilic; 7, cephalic; A, ligature.

Arteriotomy is the operation of bleeding from an artery. It is practised but rarely. The temporal artery is the one usually chosen. It should be opened by an incision at right angles with its axis, and the incision should be made to include only a part of the circumference of the vessel. When the required amount of blood has been obtained, the artery should be divided completely across, and the wound dressed in the ordinary way.

General blood-letting was in former times one of the most frequently employed therapeutical measures, as it is now one of the rarest. It is essentially depleting, and is, of course, to be avoided in all asthenic conditions. In general, it may be said to be indicated in sthenic febrile conditions, occurring in the previously robust, in which there is imminent danger of cardiac paralysis from overdistention. It may also be practised with benefit in the case of plethoric females suffering from amenorrhœa, from suddenly arrested menstruation, or from the disorders incident to the change of life. It may sometimes be possible to avert a threatened cerebral hæmorrhage by prompt and full bleeding; but when once the apoplectic attack has occurred, the time for venesection is past, unless it be evident that the hæmorrhage still continues.

Local blood-letting, sometimes called arteriophlebotomy, is employed to relieve congestion and inflammation when confined to one organ or one part of the body. In one or other of its forms it is frequently employed at the present day, finding its application in the treatment of many affections for which general bleeding was formerly prescribed. Blood may be withdrawn directly from the part inflamed, or from regions more or less remote from the local disease.

Leeches (see article Leech) are best applied by means of a glass tube (Fig. 459) or a paper cone, in which they are placed so that their buccal extremity will come in contact with the skin of the part over which the tube is placed. When they refuse to take hold, they may be induced to do so if the skin be moistened with a drop of milk or of blood. An excellent method of causing them to bite is to rub the skin for a few seconds with a little sugared water; they will then be found to take hold with avidity. If it be desired, the flow of blood may be kept up, after the leeches have dropped off, by means of warm fomentations. Occasionally the leech-bites continue to bleed long after the animals have loosened their hold, requiring a compress or the application of styptics to the wound. This is particularly apt to occur in children and young adolescents, and the surgeon should never in such cases leave his patient until the hæmorrhage is arrested. A neglect of this precaution has been followed by serious consequences.* If the leeches refuse to let go after they are filled, they may be forced to do so by sprinkling them with a little salt. Leeches may be used again after three or four months, but it is preferable to employ fresh ones in each case. The loss of blood from leeching often causes considerable depression, out of proportion to the actual amount of fluid withdrawn. On this account rest, and the avoidance of exertion, are advisable for some hours after the operation.


FIG. 459.—Glass Leech-tube.

Scarifications may be made with the ordinary thumb lancet, or with a little machine called the scarificator (see Fig. 460). This instrument is so constructed that, by pressing upon a knob, a number of small blades, from six to twenty, are forced down into the subcutaneous tissues. The blades have not only a downward, but also a forward, movement, by reason of which not only a puncture, but a true incision of the part is accomplished. The depth to which the knives descend is regulated by means of a screw, so that any degree of scarification, from a mere scratch of the skin to a row of deep incisions, may be obtained. Warm fomentations may be employed to promote the hæmorrhage after this operation.


FIG. 460.—The Scarificator.

The flow of blood may be very materially augmented by the application of cupping-glasses over the incisions. This is the procedure known as cut-cupping or wet-cupping. The cups should be first applied, and then, when the tissues are deeply congested, they are incised by the lancet or the scarificator, and the cups are again applied. Several different instruments have been devised, by means of which the integument may be scari-

* An explanation of the difficulty, occasionally experienced, in arresting hæmorrhage after leech-bites, is afforded by Professor Haycraft, who found that the leech secretes, from its sucker and gullet, a juice which prevents the coagulation of the blood. It has even been suggested that this juice might be used in the operation of immediate transfusion to prevent clotting, a small quantity being introduced into the blood current of the donor a short time prior to the commencement of the operation.

fied without removing the cupping-glass. These are sometimes called artificial leeches. They are all more or less complicated and expensive, although saving considerable time and trouble.

Another procedure, closely allied to blood-letting, and in many cases preferable to it, is the temporary withdrawal of blood from the general circulation or from a certain region. It may take the place of general bleeding in cases in which the latter may seem indicated, but in which, owing to the weakened condition of the patient, its ultimate results would be likely to be far from beneficial. The temporary withdrawal of blood in large quantity from the general circulation is accomplished by applying a ligature around one of the limbs, so as to obstruct the flow of blood through the efferent vessels. The ligature should not be made so tight as to compress the principal artery of the limb, as that would defeat the object aimed at, but should be only snug enough to shut off the returning current of blood through the veins, at least the superficial ones. One limb, or several, may be treated according to the amount of blood that it is desired to withhold. In this way the overdistended heart is relieved of its embarrassment temporarily, and is given time in which to recuperate before being called upon again to propel the entire mass of the circulating fluid.

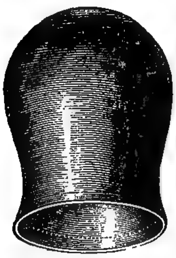


Fig. 461.—Cupping-glass. (One-third natural size.)

A local inflammation—an inflamed joint for example—may often be greatly benefited by cutting off in large part its blood supply. This is done by making compression, digital or mechanical, of the afferent artery when it is accessible. This compression need not be constant, but should be maintained for several minutes at a time at frequent intervals during the twenty-four hours.

Another and more common means of reducing congestion of a part is by cupping. By this procedure the blood is drawn to the surface, and the hyperæmia of the subjacent organs or contiguous regions of the body is relieved. Cupping may be performed with an ordinary drinking-glass or tin cup, in which the handle does not project above the rim, but it is more conveniently done with cups or glasses made for the purpose. The air within the cup is rarefied by burning in it a few drops of alcohol or a little paper, and then, immediately the flame is extinguished, the cup is inverted and applied firmly and evenly to the integument. The same purpose is accomplished by holding the glass for a few seconds over the flame of a spirit-lamp. The rim of the cup should be greased with a little vaseline or oil, so as to make it more thoroughly air-tight as it rests upon the skin. It is also advisable to moisten the skin just before the cups are applied; and they should never be placed over bony prominences or inequalities of the surface, because of the impossibility of excluding the air. Hairy parts should, of course, be shaved before an attempt is made to apply cups. Another kind of cup is made, in which the air is exhausted by means of a small air-pump; or the rounded end of the glass is attached to a rubber bulb (see Fig. 462), and the air is rarefied by applying the cup with the bulb compressed, and then allowing it to expand.

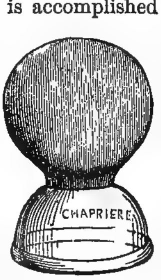


Fig. 462.—Cupping-glass, with Elastic Rubber Cap or Bulb.

Cupping is employed very frequently in acute inflammations of the brain, lungs, and kidneys. In renal congestion especially, the application of a number of wet or dry cups to the lumbar region is often of signal service. In cerebral disease the cups may be applied to the nucha, and in pulmonary inflammation to the chest-walls. Cupping of the temples in acute inflammation of the conjunctiva is frequently of benefit.

Hot foot-baths, poultices, mustard-plasters, and other forms of counter-irritation, owe much of their efficacy to the fact that they cause a temporary congestion of the parts to which they are applied, thus relieving hyperæmia in other more or less remote regions.

Thomas L. Stedman.

BLOOD-PRESSURE, Agents that Lower. Although agents that lower the blood-pressure are extensively used at the present time in the treatment of a variety of diseases, they have not as yet received any distinctive appellation; nor are they, as a distinct class, described in any work on therapeutics.

It is the object in this article to group together the more prominent of these agents, to describe their action on the circulation, and to point out in what particular pathological states they are indicated.

The following will be described under this heading: the different nitrites, nitro-glycerine, chloral hydrate, and cannabis indica. The actions of blood-letting and a dry diet in this direction will also be alluded to.

There are three nitrites which possess this power in an eminent degree; they are the nitrite of amyl, and the sodium and potassium nitrites. Although it has not been actually demonstrated, it is highly probable that all nitrites possess in a greater or less degree a similar action on the circulation.

Nitrite of Amyl.—When from three to ten drops of the nitrite of amyl are inhaled there almost immediately sets in violent action of the heart. The pulse rises rapidly to one hundred and fifty or more beats in the minute; the face and neck become markedly flushed; vessels previously invisible become visible, the temporal artery often attaining double its usual size; there is marked visible pulsation of the carotids; the retinal vessels also become dilated, as can be demonstrated with the ophthalmoscope. Persons vary much as to their susceptibility to the action of the nitrite of amyl. While three drops usually bring about the symptoms described, it is not uncommon to find persons who require more than double that amount. The writer has met a woman who required to inhale two grammes (ʒ ss.) before any flushing of the face or increased cardiac action took place.

It is said that even a fraction of a drop is capable in some people of giving rise to the full effects of the drug. This capriciousness in the action of the amyl nitrite is not always explainable by changes in its chemical composition; although there is no doubt that the drug deteriorates when long kept.

The flushing of the face, the giddiness, and the headache are due to dilatation of the arterioles. This is brought about by the direct action of the nitrite on the muscular walls of the vessels. There are two factors in operation in bringing about the quickened circulation: We have first, owing to the great dilatation of the arterioles, a demand made on the heart to fill these vessels; the second factor in the production of the rapidity of the heart's action is the depressing influence exerted upon the ends of the vagus in the heart by the nitrite. Of these two factors the former is the more important, as it is the more active. The lowering of the blood-pressure is the direct result of the dilatation of the arterioles.

From these actions of the nitrite on the circulation it follows that it diminishes the resistance to the discharge from the left ventricle.

The ventricle has not only less work to accomplish, but, owing to the rapidity of the circulation, it has more power to accomplish it. It is especially this marked power that this drug possesses in diminishing the resistance to the onward flow of the blood-stream that makes it so useful in angina pectoris.

It appears to be generally accepted that the great majority of cases of true angina pectoris are due to an actual starving of the nervous mechanism of the heart, through a cutting off of the blood-stream by spasm of the coronary arterioles.

The terrible pain is simply an expression of the want of nourishment to the organ. The great merit of not only explaining the true pathology of these cases, but also of applying to their relief nitrite of amyl, belongs to Lauder Brunton.[1] He has shown that, during the paroxysm of angina, the blood-pressure rises and the pulse

becomes quick, and that there is only a very slight difference in the pressure during the systole and diastole. As the pressure rises during an attack of angina, severe pain comes on in the region of the heart, and when the pressure falls the pain disappears. It seems clear, therefore, that there is a direct connection between the rise in the blood-pressure and the anginal attacks. That the former stands to the latter in a causative relation is further evidenced by the marked and quick relief which occurs when the nitrite is inhaled during a paroxysm. The only possible way in which this drug can act is by lowering the blood-pressure. This is an example of the Hippocratic maxim that the action of the remedy sometimes enables us to decide the nature of a disease. Nitrite of amyl has not only the power of greatly mitigating the severity of anginal attacks, but also of preventing them if it is used before they actually set in. That it at times fails to have any influence in shortening or even ameliorating the paroxysms, a few reported cases prove. What the cause of this failure is has not been definitely settled; whether it is owing to an impure preparation of the drug being used, or, what is more likely, that there are cases of angina which have for their cause a different pathological state than a spasm of the coronary arterioles.

There is another disease, resembling angina pectoris in its pathology, which is benefited by the inhalation of the nitrite of amyl. I refer to that form of hemicrania designated by Du Bois-Reymond as "Hemicrania Sympathico-tonica." In this disease we have, according to this very eminent authority, a spastic condition or tetanus of the muscular coat of the vessels on the affected side of the head. The amyl acts in these cases as it does in angina, by relieving the spastic condition of the vessels, or, in other words, by lowering the blood-pressure of the affected area. Berger,[2] Vogel and Holst,[3] Brunton,[4] and numerous others have extolled the virtues of this drug in this form of hemicrania.

Nitrite of amyl has been extensively employed to ward off epileptic attacks. This practice is based on the theory that the initial pathological factor in the production of the paroxysms is a spasm of the cerebral arterioles. What, or if any, degree of truth there is in this supposition, has not been definitely settled. The most recent views on the nature of the epileptic seizure favor the idea that, even if arterial spasm be present, it is more likely to be the result and not the cause of the attack. Whatever view is the correct one, we cannot throw aside the evidence that has been accumulating for several years, of the benefits of this agent, not alone in mitigating the severity of the paroxysms, but also of preventing them. Whether this beneficial influence is due to the power the amyl has of reducing the blood-pressure, or to its action in depressing the reflex excitability of the spinal cord (an action which in large doses it possesses in a marked degree) is not known.

That the latter is the active factor in controlling the spasms of tetanus and the convulsions of children, when the nitrite is given in these conditions, appears highly probable. It has not been proved that nitrite of amyl has any depressing influence on the cerebral motor convolutions, which we know, from the experiments of Albertoni,[5] bromide of potassium possesses.

As far as our present knowledge of the subject goes, we must conclude, therefore, that the beneficial influence of the nitrite of amyl in the true epilepsy of adults is owing to its power of reducing the cerebral blood-pressure.

The only remaining use of the blood-pressure-reducing powers of this drug that will be mentioned is its alleged antagonism to chloroform syncope. On this subject Professor Stillé says:[6] "It is certain that chloroform contracts, and that nitrite of amyl dilates, the capillaries of the brain, and of the skin of the face; under the former he grows pale, under the latter he is flushed. In experiments upon animals, if the nitrite be used in an excessive dose, cyanosis arises in consequence of venous engorgement. Experiments have also shown that if it is given according to the latter method, to an animal narcotized by chloroform, it deepens instead of relieving the narcotism; while if it be administered in moderate quantities, either by inhalation or hypodermically, it revives the heart's action and removes the pallor caused by the chloroform. These effects have been happily illustrated in at least eight cases of chloroform-poisoning. In all of them the patients were rescued from imminent death. The salutary or pernicious effects of the nitrite being due to the amount of it administered, we may explain why Jesta should have fallen into the error of declaring that it intensifies the dangers which chloroform creates. Besides the cases just mentioned of its remedial power in chloroform syncope, others might be cited to show that it is equally efficacious when injected hypodermically in the dose of three drops."

If it be correct, as Professor Stillé maintains, that the beneficial or injurious influences of this drug in chloroform-poisoning are only separated by a slight difference in the quantity given, it follows from its (at times) uncertain action that it may act sometimes quite differently from what we wish or expect. It is therefore necessary, when using it to counteract deep chloroform narcosis, to give the smallest dose.

NITRO-GLYCERINE.—The action of nitro-glycerine on the circulation is similar to that of the nitrite of amyl. It causes a marked fall in the blood-pressure from its power of dilating the arterioles and capillaries. The rapidity of the pulse is much increased, this being due to the increased demand made on the heart to fill the suddenly distended vessels, and to the depressing influence exerted on the peripheral terminations of the vagus in the heart.

The only difference in action between the nitrite of amyl and nitro-glycerine on the circulation is the difference in the length of time their effects last and the time it takes to bring them about. Nitrite of amyl acts almost immediately after its inhalation, while nitro-glycerine takes from five to ten minutes. The vaso-dilating effects of a full dose of nitro-glycerine are fully of an hour's duration, while the similar effects induced by the amyl nitrite disappear completely within five minutes. Although the effects of the latter drug are more transient, they are more decided while present. Nitro-glycerine having the same physiological effects as the amyl nitrite it is used in the same diseases and with a considerable amount of success. It is highly recommended both by Ringer and Murell as a substitute for the amyl in angina pectoris. In some cases it is undoubtedly superior, but generally it is too slow in its action to be of much avail in shortening the paroxysms. It is specially indicated in rapidly recurring anginal attacks, to prevent the paroxysms, while the amyl is of use only during the paroxysms. That nitro-glycerine has the power, when given continuously, of preventing anginal attacks is abundantly proved by the experience of Murell.[7] In order to obtain these effects it is necessary, however, to keep the system more or less continuously under its influence. From this it follows that not more than an hour should intervene during the waking hours between the doses. Given a case of angina pectoris, when the "spasms" come on frequently, the best treatment would be the continuous administration of nitro-glycerine, and the use of the amyl nitrite during the attacks. We can only expect palliation from either agent, no matter whether the cause be "functional" or "organic."

Although only palliative, their use has no doubt prolonged many lives and has rendered bearable in numberless instances a distress to which there is no parallel in all the painful troubles that man is prone to.

During the last few years a number of isolated cases of epilepsy have been reported treated with nitro-glycerine, and, according to the reporters, with marked success. When speaking of the actions of nitrite of amyl I referred to the possibility of its favorable action in this disease being in a measure due to its motor-depressant action. It is more than likely that a similar action on the part of nitro-glycerine plays an important rôle in bringing about its usefulness in epilepsy. It is, therefore, not fair to attribute its entire usefulness in this disease to its vaso-dilating action on the cerebral arterioles.

Dr. Hammond claims that nitro-glycerine has a powerful influence not only in mitigating, but even in completely preventing migrainous attacks of the sympathicotonic variety.

Mayo Robson,[8] Bartholow, and many others recommend nitro-glycerine in albuminuria. Bartholow says that it should be given after the acute symptoms have passed off, especially where there is marked increased arterial tension. It is indicated, he says, "in chronic cases at all periods, but it is especially useful if given before hypertrophy of the muscular layer of the arterioles has taken place."

High blood-pressure gives the earliest indication of the grave series of degenerative changes throughout the body known as chronic Bright's disease, and may, if neglected, lead to disastrous results, in disease both of the arteries and of the heart. When this condition of the arterial system is extreme, we can feel the persistence of the pulse by means of the finger alone. The artery is rigid, not from any thickening of its coats, but from a constant hyperdistention. To counteract this condition we have no better agent than nitro-glycerine.

As the physiological actions and uses of the potassium [9] and sodium [10] nitrites resemble in every particular those of nitro-glycerine, it is not necessary to give a separate description of them.

The dose of each of these compounds varies from twenty (3 grains) to fifty centigrammes (7½ grains).

Observing that nitrite of amyl, sodium nitrite, potassium nitrite, and nitro-glycerine had all similar actions, it occurred to Matthew Hay that this must be due to some agent common to them all. As the three former contain nitrous acid, he suspected that nitro-glycerine, which is a nitrate of glycerl, underwent a change in the blood. This he has demonstrated by showing that the alkali of the blood decomposes it, liberating nitrous acid. Nitrous acid is, therefore, the active agent in bringing about the actions of these different agents on the circulation.

Chloral Hydrate.—This drug has a marked effect in lowering the blood-pressure, through its action in depressing the vaso-motor centre, and in producing a direct effect on the muscular coat of the arterioles. In addition, it has a direct influence on the heart itself, slowing and enfeebling its movements, by diminishing the irritability of the intracardiac ganglia. It is, therefore, a cardiac depressant as well as a reducer of blood-pressure. It is the latter action that makes it useful in the only condition which will be described here. I refer to its use in cases of endocarditis and endarteritis, after the acute stage has subsided, or what has been very fitly termed the preventive treatment of valvular lesions of the heart. Dr. Fothergill[11] strongly points out the necessity there is for rest in bed in these cases. With complete rest, together with small continuous doses of chloral, the heart is placed in the best possible condition to recuperate. By these means that increase of connective-tissue, which is accelerated by high arterial tension is prevented. Dr. Fothergill points out the great danger of giving—what is very often ordered in these cases—digitalis; for it is a well-known, but unfortunately not commonly recognized fact, that digitalis contracts the arterioles, and thereby increases the blood-pressure, the very condition which we should do our utmost to prevent.

Cannabis Indica is another agent of undoubted value in cases of increased arterial tension. It has been shown by the writer[12] that it has a remarkable influence in ameliorating, and sometimes in actually curing, those cases of hemicrania that have for their fundamental pathological condition a contraction of the arterioles.

I am not aware of its having been used in other pathological states due to, or attended by, increased arterial tension, but, if we may judge from its physiological action, it is well worthy of a trial.

Compared with the different nitrites, with nitro-glycerine, and even with chloral hydrate, it is very slow in bringing about diminution of the blood-pressure. The influence of general blood-letting in reducing the pressure is not as great as might be expected. The reduction that it effects is also very temporary. We have proof of these two statements in Kussmaul and Tenner's experiments in removing successive slices from the cerebellum of rabbits. They found that all their animals bled to death before they could reach the conclusion of their experiments, but they found no trouble in finishing them, if they previously kept the animals on a dry diet for a period of two weeks. Deprivation of water was sufficient to bring down the blood-pressure. The result of this experiment goes to show that a dry diet is superior to blood-letting as a reducer of arterial tension, when we want a permanent effect.

James Stewart.

[1] Therapeutics and Pharmacology, p. 140.
[2] Ber. Klin. Woch., No. 2, 1867.
[3] Quoted by Eulenburg and Guttmann in Sympathetic System of Nerves, p. 69.
[4] Pharmacology and Therapeutics, p. 143. [5] See Motor Depressants.
[6] National Dispensatory, p. 193. [7] Lancet, 1879, vol. ii., p. 225.
[8] British Medical Journal, November 20, 1880.
[9] Reichert: American Journal of Medical Science, July, 1880.
[10] Matthew Hay: Practitioner, 1882.
[11] Practitioner, January, 1881, and Brit. Med. Jour., November, 1884.
[12] Canada Med. and Surg. Jour., October, 1880.

BLOODROOT (*Sanguinaria*, U. S. Ph.), *Sanguinaria canadensis* Linn.; Order, *Papaveraceæ*, is the only species in the genus. It is a low perennial, with a thick, fleshy, horizontal root-stock, from which one or two leaves and a single handsome white flower appear early in the spring, enclosed at the base by several sheathing scales. The leaves are kidney-shaped, variously lobed, and grow much larger and broader as the season goes on. The flower is about three centimetres across (one and a fourth inch), regular, perfect, spreading; sepals two, falling early; petals from six to twelve, rather narrow; stamens numerous, ovary and capsule one-celled, with two placentas; ovules (and seeds) numerous, with prominent caruncles. An opaque, orange-colored juice is found in all parts of the plant, especially in the root, where it is very abundant and dark. Bloodroot is a native of North America, and is occasionally cultivated as an ornamental plant both here and in Europe. The dried root is about five centimetres long (two inches), and one centimetre in diameter, slightly flattened, indistinctly annulated, and evidently shrunken and wrinkled. It is reddish brown externally, variously bent and twisted, and now and then branched. It breaks with a short fracture, and displays a pink surface, finely dotted with dull-red points; this surface becomes dark by exposure, and finally is uniformly brownish red. Odor slight, disagreeable. Taste bitter, acrid, nauseous, and persistent. Powder sternutatory.

Fig. 463.

The principal constituent is the alkaloid *sanguinarine*, discovered and named by Dana in 1829, and identical with the "chelerythrine" of Celandine, separated in 1837 by Probst. When pure it is in white crystalline needles or tufts, insoluble in water, but easily dissolved by alcohol, ether, oils, etc.; it forms with the principal acids beautiful salts of brilliant orange or red color. The powder excites violent sneezing. Its taste, when dissolved, is that of the rhizome intensified. One or two other alkaloids of doubtful identity have also been described as existing in bloodroot, but this is the only one of importance.

Action.—Vomiting, purging, and general depression, are the prominent symptoms of both the crude medicine and its alkaloid. It is an active poison; alarming effects, and even death, have followed its administration. Blood-root itself has been considerably used as an emetic and nauseant, but is harsh and depressing, and, at present, has fallen into comparative disuse in regular medicine. It is occasionally put into cough-mixtures as an expectorant, but ipecac is to be preferred even for this purpose. As an alterative, and for various remote effects, it is wholly obsolete.

Doses: One gramme (gr. xv.) will usually procure vomiting and make the patient very uncomfortable; from five to twenty-five centigrammes (gr. j. ad iv.) may be given as an expectorant; the latter dose will, perhaps, nauseate if frequently repeated. The preparations are, fluid extract (*Extractum Sanguinariæ Fluidum*, U. S. Ph.), strength, $\frac{1}{1}$; vinegar (*Acetum Sanguinariæ*, U. S. Ph.), strength, $\frac{15}{100}$, whose doses may be calculated from the above. *Sanguinarine* has been given experimentally; the doses appear to be, as an expectorant, from five to eight milligrammes (0.005 to 0.008 Gm. = gr. $\frac{1}{12}$ ad $\frac{1}{8}$); as a nauseant, from one to one and one-half centigramme (0.01 to 0.015 Gm. = gr. $\frac{1}{6}$ ad $\frac{1}{4}$); as an emetic, three centigrammes (0.03 Gm. = gr. $\frac{1}{2}$). The sanguinarine of the market is always red, probably either a salt or contaminated with one.

The eclectic "Sanguinarin" is a precipitate from the tincture, and not the alkaloid.

Allied Plants.—See Opium for the Order *Papaveraceæ.*

Allied Drugs. — Celandine (*Chellidonium majus* Linn.) also contains the alkaloid of bloodroot, and has similar but milder qualities. *Eschscholtzia* and other *Papaveraceæ* with orange-colored juice may probably be considered as of similar properties. Tartar emetic in full doses may also be compared with it. For a further list of emetics see Ipecac. *W. P. Bolles.*

BLOOD-STAINS. In criminal trials the medical witness is often called to determine whether stains found on weapons—as knives, clubs, or daggers—or upon the clothing of a suspected person, or upon the floor, walls, or ground where a homicide is supposed to have been committed, were caused by blood or by some other coloring matter. So also it is often equally important to determine whether stains acknowledged to be blood are the blood of a human being or the blood of one of the lower animals. The object of this article is to show how, and to what extent, these important questions may be answered. Such investigations have often served to convict the guilty, and in other cases to triumphantly acquit the innocent.

The examination of blood-stains calls for the consideration of, 1, physical characteristics; 2, chemical reactions; 3, crystalline properties; 4, optical properties; and 5, microscopical appearances of blood-corpuscles and other constituents of blood.

Physical Appearances of Blood-stains. — The color of blood-stains varies with the amount of serum, and the absorbent properties of the object upon which it dries. Generally the more permeable the tissue or object stained, the brighter is the color after blood has dried upon it.

Upon polished steel or other metal, blood dries in dark, brown, shiny scales, however thin the layer of blood may be. Upon silk or upon glass it assumes about the same color as upon polished metal. Upon varnished or very hard wood, blood-stains have also a dark shining surface. But upon soft porous wood, or any soft tissue, as cotton-cloth, the color is dull brown or rose tint, yet even on cloth a thick clot, when dry, presents a brown but glistening surface.

It sometimes happens that upon tissues or objects of a brown, maroon, or dark-blue color, blood-stains are quite invisible by full daylight, but they become conspicuous by artificial light, especially if examined by light obliquely reflected. This is especially the case with dark-colored furniture, wall-paper, or any dark paint on which blood-stains easily seen by the light of a candle are quite invisible by daylight.

Stains upon steel or other metallic instruments, if quickly dried by exposure to the air, are cracked and of a fine red color; but stains on similar instruments, kept in a damp situation, are of a dirty brown, tending toward a rusty yellow color, surrounded with an ochrey areola, yielding no color or albumen to water; even a solution of potash extracts only a small quantity of albumen.

Upon glass, marble, plaster, flint, sandstone, and earth, blood-stains preserve their ordinary characteristics; but upon wood containing tannin they form with the tannin an insoluble compound, and water in which such stains are macerated fails to yield characteristics of blood. In such cases the surface can sometimes be scraped off and tested free from the tannin.

On felt and some kinds of cloth, blood forms shiny spots appearing like mucilage. In examining garments, searching for blood-stains, a small magnifying-glass is of great service in distinguishing small specks or drops of blood.

Chemical Reactions.—(a) *Guaiacum Test for Blood.*—If any red substance is suspected to be blood, place a drop on white blotting-paper, or if dry, moisten with water and place it on the paper. Let fall upon the stain thus formed a drop of tincture of guaiacum. If the stain turns blue, with no other treatment, it is not blood, or if it contains blood it also contains starch, a salt of iron, or some other foreign substance. If it does not turn blue by the action of the guaiacum, drop upon it a little watery solution of peroxide of hydrogen, when, if it is blood, it will quickly assume a beautiful sapphire-blue color. A particle of blood which is scarcely visible to the naked eye may be detected by this test.

Fallacies of the Guaiacum Test.—If guaiacum and peroxide of hydrogen are mixed before application, many substances give results similar to that of blood. Always apply the tincture of guaiacum first, and add the hydrogen peroxide afterward. Oxidized guaiacum gives a blue color with hydrogen peroxide without blood. Always make a fresh tincture from the inner portion of pearls of the gum. The hydrogen peroxide should be pure. If nitrate of silver gives a copious precipitate with the hydrogen peroxide, it is unfit for use.

Iron rust alone does not turn guaiacum blue with hydrogen peroxide.

Iron blades rusted with fruit-juice (citric acid) turn blue with guaiacum without hydrogen peroxide.

Perchloride of iron turns guaiacum an indigo blue without blood and without hydrogen peroxide. Any acid containing iron vitiates the guaiacum test. Some kinds of paper sized with alum contain iron, and turn blue with guaiacum. Wheat flour (gluten) blues guaiacum without peroxide. Starched paper or cloth turns guaiacum blue. If the blue color is not produced by the tincture of guaiacum alone, and if hydrogen peroxide is then added and produces the blue suddenly, the substance examined is almost certainly blood.

If the stain be on dark cloth and no particles can be removed to white paper (pure white paper, free from alum or iron is alone fit for use with this test) it may be moistened with water and then treated with tincture of guaiacum and hydro-peroxide. It may then be pressed upon white paper, and if blood be present the blue color will be printed on the paper.

(b) *Action of Solvents and other Reagents.*—Stains upon cloth, supposed to be blood, may be cut out with scissors and suspended by a thread in a small test-tube containing distilled water. The bottom of the cloth should dip into the water, but the stain should not touch the sides of the tube. In this condition the coloring matter of blood will generally detach itself from the tissue and fall in reddish striæ to the bottom of the tube. On withdrawing the cloth after some hours' soaking, it will be found covered with a soft grayish substance, easily removed with the finger-nail or with a scalpel; this is fibrin. The water on agitation assumes a rose or red color, varying with the amount of coloring matter dissolved. Heating causes a deposit of gray flocculi, which are a mixture of fibrin

and albumen. These flocculi are readily dissolved by liquor potassæ, and the resulting liquid has a reddish hue by reflected and a greenish tint by transmitted light—dichroism. Chlorine, hydrochloric acid, or nitric acid, causes the flocculi to reappear.

"When a solution of blood has been coagulated by heat and redissolved by liquor potassæ, the coagulum may be made to reappear by the addition of nitric acid. The blood solution has also the characteristic property of not being changed in color by the addition of a small quantity of liquor ammoniæ. No other red solutions have these two characteristics. The red, pink, or scarlet infusions of flowers and roots, and the juices of fruits, are changed to green or violet by ammonia, and cochineal to crimson. The red solution of *sulphocyanide of iron* yields with the same reagent a white precipitate of oxide of iron, and the pink solution of permanganate of potash is changed to blue. Blood solutions yield a red precipitate to infusion or tincture of galls; but red coloring matters, due to the presence of salts of iron, yield a dark blue precipitate" (Guy and Ferrier).

When a solution of blood is heated the color disappears, but vegetable colors in general are unchanged by heat.

If many stains are to be examined, care should be taken to number them and affix the same numbers to the vessels in which they are placed for examination; also to carefully describe in writing the form, dimensions, and position of each of the stains. If the stains are upon weapons, from which it is not possible to detach a superficial layer, they may be moistened with drops of water. If they are upon wood, plastered wall, or stone we may scrape the surface and test the material removed. If upon the point of a dagger or other narrow blade, it may be placed in a tall, narrow vessel. In general, if the material of the stain can be scraped off, the fine powder thus obtained may be treated with a minute portion of fluid in a test-tube or watch-glass, or on a concave slide or cover-glass, such as is used with the microscope. The method of dealing with minute specks, when no more can be obtained from a stain, will be described further on. If the powder obtained is abundant and contains foreign matter, it may be placed in a small gauze bag and suspended in a test-tube as described above. If the stains are spread in streaks on the surface of the instrument, a plate of glass may be arranged on a perfect level and a few drops of distilled water may be placed on the glass and the instrument so arranged that the stain will touch the water while the instrument does not touch the glass. After one or two hours the water will be colored by the stain. But whatever process we employ, it is important to avoid contact of water with the steel or iron so as to form rust. In all cases a small quantity of water only should be used, and if the liquid contains much foreign matter, it should be filtered before using reagents. Persos has proposed the use of hypochlorous acid as a means of recognizing blood-stains. This acid is prepared by passing chlorine, well washed, into a solution of oxide of mercury in distilled water, and distilling the acid thus formed. This acid quickly destroys all organic coloring matters, except blood, which withstands the acid much longer than other colors. Two minutes are sufficient to destroy most colors, except that of blood.

Stains of colcothar and grease and those of rust resist for a long time the action of hypochlorous acid, but disappear instantly by contact with chloride of tin, which does not act upon the coloring matter of blood. Carbon mixed with the colored fluid cannot be readily decolorized by any reagent. Aqua ammoniæ in small quantity added to a solution of blood does not discharge the color, it only makes it slightly darker.

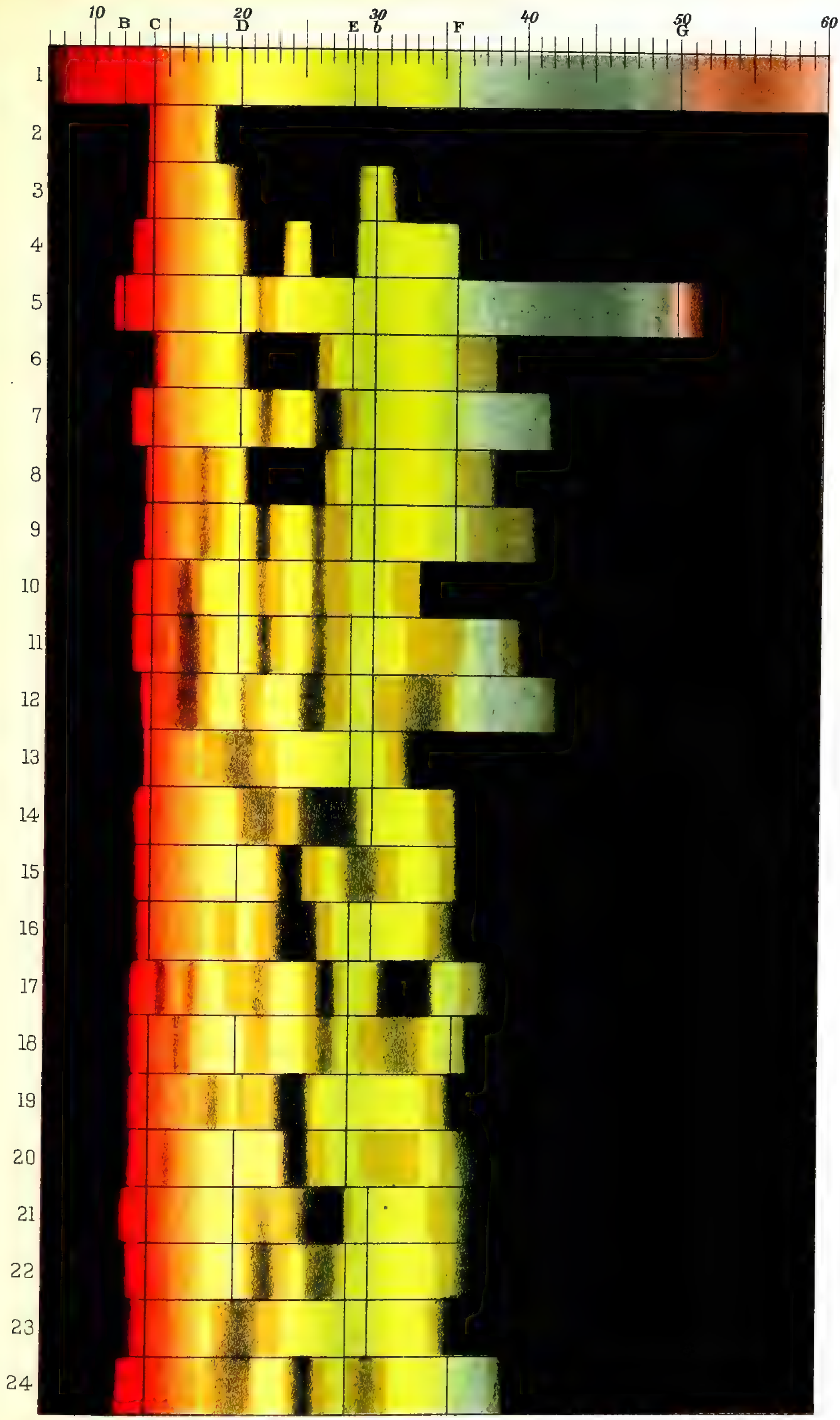
Crystalline Properties.—*Crystals characteristic of blood* were discovered by Teichmann, and great importance is attached to this test. To obtain these *hæmin* crystals, digest the stained tissue (or better, the powder obtained from it) for twenty-four hours in glacial acetic acid, to which has been added a trace of chloride of sodium. Place a drop of the red fluid obtained upon a glass slide, and allow it to evaporate at a temperature of from 80° to 100° F. Some advise a temperature of 180° F. If the coloring matter has been obtained in water, evaporate to dryness and then apply a drop of glacial acetic acid with a trace of chloride of sodium. As the fluid evaporates, a great number of crystals appear, in the form of rhomboidal plates of yellow, red, or brown color, depending on the thickness of the crystalline plates. Frequently the crystals form regular lozenges. If the stain is on cloth, boiling in a test-tube with acetic acid facilitates the removal of the coloring matter. The formation of these crystals is prevented by excessive heat, alcohol, and any acid except acetic acid. Ammoniacal alcohol (alcohol with one-twentieth part aqua ammoniæ) is employed with advantage for treating these stains. The red liquid which it produces furnishes crystals as it evaporates. With recent blood-stains it is seldom necessary to add chloride of sodium to obtain the crystals. The crystals obtained by the processes above described are known as hæmin crystals.

Crystals of the unchanged coloring matter of blood are obtained by other methods, and vary much in form in different animals. In the dog and in man they are long parallelograms, in the squirrel they are hexagonal plates, and in the Guinea-pig they are in the form of tetrahedral crystals. Crystals of hæmin which are obtained in testing for blood, according to Teichmann, are of the same form whatever the animal from which the blood may have been obtained. They are oblique rhomboidal prisms with acute angles of about 55° and obtuse angles of 125°, varying with the position in which they are seen. These crystals are often placed over each other in the form of a Maltese cross. The angle made by the arms of the cross is said to vary in blood from different animals. The length of these crystals, as obtained from human blood, is from one and a half to three times greater than the breadth. In crystals obtained from the blood of a chicken, the length of some crystals is four and a half times greater than the breadth, and in crystals from the blood of the mouse the difference is much greater.

Chloride of sodium is one of the normal constituents of human blood, and it sometimes appears in the form of cubical crystals in testing for blood, when no chloride of sodium has been added to the preparation. Dagger-shaped crystals, resembling crystals of muriate of ammonia, are sometimes found. Hæmin crystals from human blood are generally very small, and, if obtained from minute stains, their obtuse angles are somewhat rounded, as are crystals of uric acid, found as a brick-dust sediment in urine, and not like the fine-cut angles seen when uric acid is crystallized from a pure solution prepared by chemical means. Dr. A. S. Taylor, in his treatise on "Medical Jurisprudence," figures many forms of blood crystals obtained under different conditions and from different animals.

Wilbrand, in the Edinburgh *Medical Journal*, 1862, p. 371, says: "Crystals from human blood have a length from one and a half to three times their breadth. Crystals from blood of the ox and mouse (we might add also the dog) are from six to ten times longer than their breadth." If an extended series of observations should confirm these statements, the results might be of great importance. Crystals from the blood of the ox are often arranged as six-rayed stars (the same is true with crystals from human blood). Crystals from the blood of the mouse form rectangular crosses, and oblique crosses with acute angles of rather more than sixty degrees. Some recent writers express the hope of distinguishing the blood of man from that of the domestic animals by the crystals obtained; but, although this idea has been before the public for twenty years, it does not now seem likely that any important distinctions will be made by that method. But at present all we can say is, that when well-marked hæmin crystals are obtained, we may be very certain that the stain is blood, though it may still be blood if no hæmin crystals are formed. Some specimens of acetic acid, owing to peculiarities not yet understood, prevent the crystallization of the coloring matter of blood.

PLATE II.



BLOOD SPECTRA.

SPECTRUM ANALYSIS OF BLOOD-STAINS.—One of the most important methods of distinguishing colored solutions of blood-stains from other colored fluids, is by the use of the spectroscope. The peculiar spectra produced by the passage of light through solutions of blood were noticed by Hoppe in 1862, and were suggested by him as a means of medico-legal research. Stokes, in 1864, and Sorby, Lethby, MacMunn, and others, have added largely to our knowledge of this subject.

The coloring matter of fresh blood is known as hæmoglobin, and, according to Preyer, it contains nearly all the iron of the blood. By the action of reagents, such as acetic, tartaric, and citric acids, the *bright red* of fresh blood becomes changed to a *brownish red,* known as hæmatin. This is a permanent chemical change. The same change of hæmoglobin into hæmatin takes place when blood has been kept for a long time. The fresh blood-stain is bright red (hæmoglobin), the old stain is brown (hæmatin).

Hæmoglobin and hæmatin are each capable of existing in two states of oxidation, each state producing in the spectrum its own characteristic absorption bands.

If a blood-stain is kept in a damp place, the hæmoglobin is rapidly changed into hæmatin, or both hæmoglobin and hæmatin may be decomposed. But if the stain is kept dry, it becomes in time of a brown color. This change is hastened if the stain is exposed to a strong light. This brown coloring matter is *methæmoglobin,* which Sorby regards as peroxidized hæmoglobin. This alteration is much more rapid in an atmosphere containing coal-gas, or a trace of sulphurous or any other weak acid. The change is also very rapid when a stained garment is worn next to the skin, as the acid perspiration hastens the change.

If the color of a blood-stain is a bright red it is evident that it is recent, but if it be brown it is not necessarily an old stain.

In illustration of the use of the spectroscope in the examination of blood-stains, reference is made to Plate II., copied from the work of Chas. A. MacMunn, B.A., M.D., London, 1880, entitled "The Spectroscope in Medicine."

EXPLANATION OF PLATE II.

Spectrum.

1.—Solar spectrum, with Fraunhofer's lines; the latter are shown in all the spectra for comparison.
2.—Strong solution of oxyhæmoglobin.
3.—Weaker solution.
4.—Still weaker, showing two oxyhæmoglobin bands.
5.—The solution diluted sufficiently to show only one band.
6.—Reduced hæmoglobin.
7.—Carbonic-oxide hæmoglobin.
8.—Sulphæmoglobin.
9.—The same oxygenated.
10.—Methæmoglobin.
11.—Blood treated with nitrite of amyl and alcohol.
12.—Acid hæmatin (alcoholic solution).
13.—Alkaline hæmatin (alcoholic solution).
14.—Blood treated with alcohol and ammonia.
15.—Reduced or deoxidized hæmatin.
16.—Sulphate of cruentin.
17.—Five-banded alkaline cruentin.
18.—Neutral cruentin in chloroform.
19.—Hydrochloric product from neutral cruentin.
20.—Reduced cruentin.
21.—Blood treated with cyanide of potassium or with hydrocyanic acid.
22.—The same deoxidized.
23.—Solution of blood treated with solution of bromine.
24.—The last reduced with ammonium sulphide.

All the above are mapped from the micro-spectroscope.

The spectra shown in Plate II. may be prepared by the following simple methods, given by MacMunn:

Alkaline Hæmatin.—Make a saturated solution of carbonate of potash in alcohol, and pour a few drops of blood into the solution; the color of the blood immediately changes, and, when examined, the spectrum shown in Plate II., Sp. 13, is seen, a broad lightly shaded band covering Fraunhofer's line D. The action of caustic alkalies on defibrinated fresh cat's blood was found to give different spectra from those often described. Caustic potash and caustic soda in alcohol when added to blood give the same spectrum, but different from that produced by aqua ammoniæ or by carbonate of potash. It consists of three bands, two of which are like the bands of fresh blood, but, on the addition of a reducing agent, the spectrum of reduced hæmatin appears.

An ammoniacal solution of alcohol added to blood gives a faint band in the red and a darker band nearer the violet. On dilution of the mixture the band near the violet divides into two, and on the addition of a reducing agent the bands of reduced hæmatin appear (see Plate II., Sp. 14). This band in the red is feeble, and if old blood is used it is seldom seen.

Reduced Hæmatin.—This can be obtained by adding ammonium sulphide to a solution of blood treated by alcohol and carbonate of potash, or by the alcoholic solution of caustic soda or of caustic potash, or of ammonia; but if an alkali alone be added to blood previously, the reducing agent will not develop this spectrum. Sp. 15, Plate II., is that of reduced hæmatin.

Acid Hæmatin.—Add a few drops of acetic acid to blood and shake with ether; the brown-red ethereal solution gives four well-marked bands. This spectrum is shown in Plate II., Sp. 12. The feeble band near D is not readily seen with that degree of dilution which shows the bands in the green to the best advantage. By narrowing the slit of the micro-spectroscope and focusing carefully the bands are made to appear.

Action of Bromine on Blood.—(1) Ox-blood treated with bromine and shaken with alcohol gives four absorption bands, which are practically identical with those of acid hæmatin.

(2) Ammonium sulphide added to this gives not only the bands of reduced hæmatin, but a third feeble band in orange, close upon D (see Plate II., Sp. 24).

(3) If ammonia be added to the first solution it develops a band at D, like that of alkaline hæmatin.

(4) Ammonium sulphide added to this develops the same bands as in (2).

(5) A solution of blood treated with an aqueous solution of bromine gives a band just like alkaline hæmatin, or that of (3). (Plate II., Sp. 23.)

Sulphate of Cruentin.—Boil defibrinated blood with strong sulphuric acid, add water and filter; wash the mass on the filter until the washings are neutral to test-paper, and dry. This precipitate is what Thudichum calls *cruentin.* Dissolve some in sulphuric acid, it produces a fine ruby-red color, giving two absorption bands; this is the spectrum of sulphate of cruentin (Sp. 16, Plate II.).

Alkaline Cruentin.—Dissolve some of the neutral dried precipitate of the last experiment in alcohol and ammonia, when a red fluid will be obtained giving five (or four) bands (Sp. 17, Plate II.).

Neutral Cruentin.—Dissolve some of the neutral dried precipitate in chloroform; this gives four bands, but differing in their positions from those of alkaline cruentin (Sp. 18, Plate II.).

Hydrochloric Product of Neutral Cruentin.—Add hydrochloric acid to the last fluid, it becomes turbid; heat, the turbidity disappears; it is now of a purplish color and gives three bands (Sp. 19, Plate II.).

Reduced Cruentin.—Add ammonium sulphide to the alkaline solution of cruentin; this solution gives three bands, which are shown in Plate II., Sp. 20. The darkest band of this spectrum is nearly in the same place as the first reduced hæmatin band.

Methæmoglobin.—Add a solution of permanganate of potassium to a solution of blood; notice the position of the band in the red. This is the only band of importance; it is shown in Sp. 10, Plate II., in which the other bands are also seen. Dilute and add ammonium sulphide; notice the band of reduced hæmoglobin, while the band in the red disappears.

Sulphæmoglobin.—Pass sulphuretted hydrogen for some time through a solution of blood; in this case also a band appears in the red, but there is also a broad dark band in the position of that of reduced hæmoglobin (see Plate II., Sp. 8). On shaking with air this band is replaced by two (Sp. 9). Add ammonium sulphide, and the band in the red still remains, thus presenting a contrast to methæmoglobin, in which the band in the red disappeared.

Cyanhæmatin.—Add a solution of cyanide of potassium to a solution of blood and *heat gently for some time;* the blood bands disappear and a band is developed shown in Sp. 21, Plate II. Add a reducing agent and two other

bands appear nearly in the position of the blood-bands but nearer the violet (Plate II., Sp. 22).

CO Hæmoglobin.—Pass coal-gas through a solution of blood for some time, the solution becomes red and looks clearer than before; examine with the spectroscope, two bands are seen nearer the violet than the normal blood bands. Add ammonium sulphide, no effect is produced (Plate II., Sp. 7).

INSTRUMENTS FOR SPECTRUM ANALYSIS OF BLOOD-STAINS.—As the absorption-bands produced by colored fluids are broad and not very sharply defined, an instrument of much less dispersive power than that used for colored flames is required. The micro-spectroscope made by R. & J Beck, to be attached to the microscope instead of the objective is very useful where the quantity of coloring matter is considerable, as it allows the use of the micrometer in the eye-pieces of the microscope to mark the position of absorption-bands. Where the quantity of coloring matter is small, as is often the case in legal investigations, the writer prefers the improved micro-spectroscope of his own invention, shown in Fig. 465. This instrument is inserted in the microscope instead of the ordinary eye-piece, and any objective may be used which is found most convenient for examining the object.

The micro-spectroscope used by the writer of this article consists essentially of a spectroscopic eye-piece like the simplest form of the Sorby-Browning micro-spectroscope, as it is called, with removable prism; above the instrument thus constructed is placed a small telescope with no magnifying power whatever, the lens and eye-pieces being of equal power, having a Jackson's micrometer inserted in the eye-piece.

To describe it more in detail, I would say that there is,

1. A double convex lens of about two inches focal length.

2. About an inch above this is placed a slit formed by two knife-edges of London black glass, moving by double

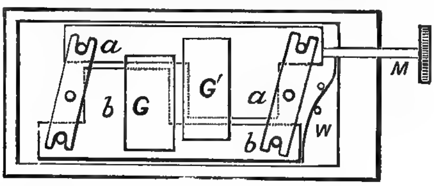


FIG. 464.

parallel motions, both knife-edges approaching the centre simultaneously.

In Fig. 464 two knife-edges of black glass are cemented to the parallel bars *a a* and *b b*, which are moved simultaneously in opposite directions by the screw *M*. When the screw is released, the slit is opened by the action of the spring *W*.

3. An achromatic collimating lens of one and one-half inch focus, with the slit in focus of this lens.

4. Directly above this achromatic lens is the compound direct vision prism, formed of three prisms of crown glass and two of dense flint glass.

5. A telescope achromatic field lens of about one and one-half inch focus.

6. Above this a Kellner negative eye-piece, carrying in its focus a Jackson's micrometer.

Fig. 465 shows the construction of the improved micro-spectroscope, which is inserted like an eye-piece into the body of the microscope by the tube *A*. *M* is the improved slit of Fig. 464, inserted into the spectroscope. *F* is the field lens. *P* is a prism to admit the ray *S s V*, to form the comparison spectrum. The rack-work *R* is used to adjust the focal distance of the collimating lens *E*. The direct vision prism *V V'* can be swung aside on the pivot at *C* to allow of focusing an object on the stage as in the micro-spectroscope of C. Zeiss.

T T' is the micrometer telescope with the Jackson's screw micrometer *M'*, on which the absortion-bands are focused so as to be visible with the micrometer lines by the eye placed at *E*. This micrometer telescope can be removed for preliminary work, and replaced when it is desired to measure the exact position of absorption-bands. There is no aberration of the micrometer lines when the eye is moved from side to side.

When this instrument is carefully focused the micrometer lines are clearly seen lying over the spectrum, marking exactly the position of all the Fraunhofer lines seen by daylight, and the exact position of every absorption-band belonging to the object under observation, with not the least trace of aberration as the eye is moved from side to side. This advantage does not attach to any other micro-spectroscope yet constructed, so far as I am acquainted.

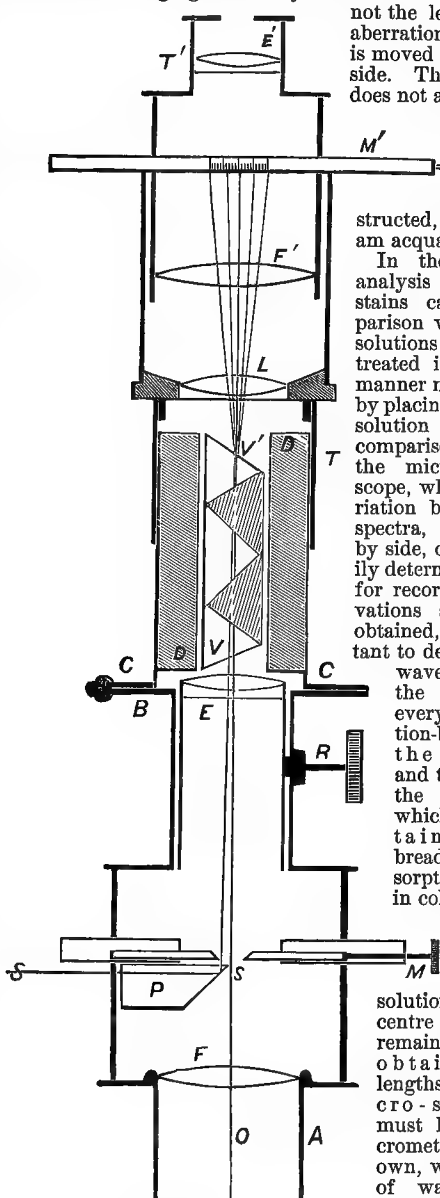


FIG. 465.

In the spectrum analysis of blood-stains careful comparison with known solutions of blood treated in the same manner may be made by placing the known solution before the comparison prism of the micro-spectroscope, when any variation between the spectra, placed side by side, can be readily determined. But for recording observations and results obtained, it is important to determine the wave-length of the centre of every absorption-band, noting the conditions and treatment of the stain by which it was obtained. The breadth of absorption-bands in colored fluids varies with the strength of the solution, but the centre of the band remains fixed. To obtain wave-lengths each micro-spectroscope must have a micrometer of its own, with a scale of wave-lengths carefully adjusted to the prisms and lenses used. Fig. 466, M S, shows the micrometer scale used by the writer of this article, and the spectrum, S S, immediately above it, shows the positions of the principal Fraunhofer lines of the solar spectrum as measured by this micrometer. All the spectra in this plate are drawn to the same scale, and the line D D, from the top to the bottom of the plate, is used as the starting-point from which measurements are made, and by which the position of the micrometer is adjusted. The didymium line, *b*, in spectrum 10–10, is used in the same manner for fixing the position of the scale when artificial light is employed.

Blood-Stains.

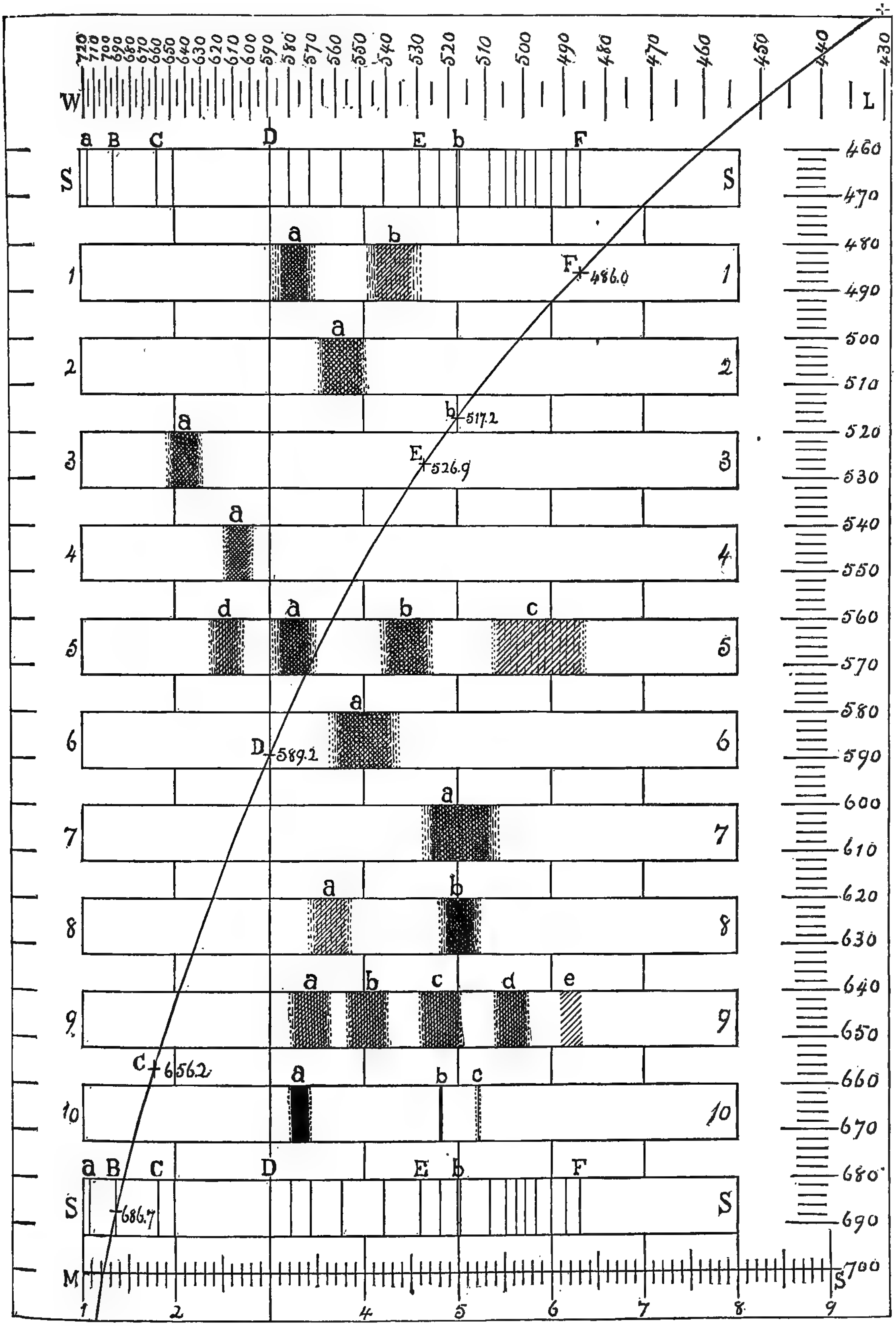


FIG. 466.—Spectometry of Blood.

The micrometer measurements may be reduced to wave-lengths by means of an interpolation curve, shown at B, C, D, E, b, F, G, constructed as follows: At the right hand is a scale of equal parts, numbered from 460 to 700. These numbers represent in millionths of a millimetre the length of all the waves of light which require to be considered in the analysis of blood-stains. Across vertical lines drawn through the Fraunhofer lines in the spectra S S, S S, horizontal lines are drawn from the scale at the right side of the plate at positions corresponding with the known wave-lengths of the Fraunhofer lines.

a = 718.5	C = 656.2	E = 526.9	F = 486.0
B = 686.7	D = 589.2	b = 517.2	G = 430.7

Through these points of intersection of the vertical and horizontal lines the curve B F is drawn. Then from points in this curve opposite to the numbers 460, 470 to 700, vertical lines being drawn, enable us to draw the scale W L, which serves to determine the wave-length of any band measured by the micrometer M S.

The position of absorption-bands thus determined may be recorded, and at any future time compared with the records of other observers.

In Fig. 466, Spectrum 1–1, at *a* and *b*, are shown the absorption-bands of normal blood drawn in their relations to the Fraunhofer lines as seen in the Sp. S–S, and their true positions on the scale of wave-lengths, W L. The band *b* is seen to be broader and paler than the band *a*. In Sp. 8–8 are shown the absorption-bands of an ammoniacal solution of carmine, where *a* is shown to be paler than *b*, and also that *b* has a wave-length 517 at its centre, while the band *b* in the spectrum of blood 1–1, *b*, has the wave-length 538.*

The Sp. 9–9 shows the positions of the five bands in a solution of permanganate of potassa. In Sp. 5–5 the bands *a b c* are produced by a solution of alkanet, where the band *a* is almost exactly like *a* in the blood-spectrum 1–1, but *b* and *c* are different. If a little alum is added to the solution of alkanet, the band *d* appears, while *a b* and *c* remain unchanged; if alum is added to a solution of blood, both the bands disappear. At *a*, in Sp. 2–2, Fig. 466, is shown the band of reduced hæmoglobin produced when hydrosulphate of ammonia is added to a solution of normal blood.

Other reducing agents produce the same effect. One of the best is made by dissolving equal parts of tartaric acid and double sulphate of iron and ammonia, and then adding a little aqua ammonia.

An ammoniacal solution of tartrate of protoxide of tin may be used as a reducing agent. It is prepared by adding tartaric acid to an aqueous solution of the protochloride of tin, and neutralizing the solution with ammonia. The acid should be added in such quantity that after over-saturation by ammonia no precipitate is formed, but a clear solution remains.

Sulphide of sodium is highly recommended by Preyer as a reducing agent. Dr. Beale recommends, as a deoxidizing solution, protosulphate of iron, with sufficient tartaric acid added to prevent precipitation by alkalis. A small quantity of this solution, made slightly alkaline by ammonia or carbonate of soda, is to be added to a weak solution of blood in water.

At *a*, in Sp. 3–3, is shown the band peculiar to acid hæmatin, wave-length 640.

At *a*, in Sp. 4–4, is the band of alkaline hæmatin, wave-length 605.

At *a*, Sp. 6–6, is shown the absorption-band of a solution of fuchsin, wave-length 548.

At *a*, Sp. 7–7, is the band produced by a solution of eosine, wave-length 517.

All absorption-bands vary in intensity and in breadth as the strength of the solution varies, but the centre of the band remains stationary.

At *a b c*, in Sp. 10, are shown a series of beautiful bands produced by a solution of sulphate of didymium. This remarkable substance, of a faint pink hue, in solution almost as colorless as water, gives a broad absorption-band *a*, central at a wave-length of 575 millionths of a millimetre, extending from 571 5 to 578. The line *b* is very sharply defined at wave-length 523 of the same scale. This substance serves as an index to fix the position of the micrometer-scale when using artificial light.

Besides the substances mentioned above, some other red solutions give absorption-bands somewhat similar to blood, but with careful manipulation and appropriate tests they may be certainly distinguished from blood. The coloring matter of the petals of the red variety of *Cineraria*, a variety of chlorophyl, gives two bands somewhat like blood, but the micrometer readily shows that they occupy different positions on the scale of wave-lengths. Add ammonia, and the blood-bands remain unchanged, while those of the *Cineraria* solution are altered or completely destroyed.

A solution of *cochineal in alum* gives the bands *a b*, Sp. 8–8, Fig. 466, differing little from those of fresh blood. Add ammonia, and in both solutions the bands become more intense. Now add excess of boric acid; in the solution of cochineal the bands shift toward the blue end of the spectrum, while with blood they remain unchanged.

The other reds likely to be confounded by the unpractised eye with blood are *lac-dye, alkanet, madder red*, and *munjeet*, dissolved in each case *in alum*.

But if the spectra be carefully examined side by side with blood, or their wave-lengths determined on the scale by their positions seen on the micrometer, it will be apparent that the bands produced by these bodies are not the same, either in position or character. Further, none of them will stand the action of ammonia, while they are all bleached with sulphite of potash, which has no action on blood. In the examination of *a mixture of magenta and blood*, the magenta bands may entirely mask those produced by blood. The various blood-spectra may, however, be easily obtained unmixed, by adding to the solution a trace of sulphite of soda, which completely removes the magenta coloring matter, but leaves the blood untouched.

All the supposed fallacies disappear if we successively obtain the various blood-spectra with the reagents already described.

Examination of a Recent, or Comparatively Recent, Blood-stain on a White Fabric.—If you can detach a portion of the blood, do so; but if this is impossible, cut out a small piece of the stained fabric, and soak it for about ten minutes in a few drops of cold distilled water in a watch-glass. Then squeeze the colored fluid out and set it aside for a short time, so that any insoluble matters may be deposited. Provide a glass cell about one-eighth of an inch in diameter, and half an inch high, which may be made of a section of barometer-tubing cemented to a slide with gutta-percha, with a diaphragm of tin-foil between the slide and the end of the tube. With a fine drawn pipette, introduce the red fluid into this cell, and place it on the stage of the microscope with an objective of low power, and illuminate with sunlight or other strong light, when, with the micro-spectroscope in place of the eye-piece, if the solution is blood, the characteristic absorption-bands will readily be seen. If there is sufficient of the solution, several tubes may be filled. If the tube contains any sediment, it may be laid on one side until the solution is clear. The objective should be focused near the top of the tube, a little below the surface of the fluid. If the blood is tolerably recent, the spectrum of oxidized hæmoglobin with its two well-defined absorption-bands in the green will be apparent, as shown in Pl. II., Sp. 4, or Fig. 466, Sp. 1-1. If such a spectrum is obtained, it is evident that it has been very little changed by exposure, and that it is probably of recent origin. If the spectrum contain two faint bands in the green, and an extra band in the red, it indicates that the stain has undergone a change. Now add a trace of ammonia to the solution in the tube, stirring it with a platinum wire, when you will obtain Sp. 4, Pl. II., with two bands in the green and none in the red.

2. To a second tube of the suspected solution add, first, a very little ammonia, and then a small quantity of Rochelle salt. With this no change will be produced in the

* The scale of wave-lengths are in millionths of a millimetre.

spectrum, the ordinary bands being visible as before. Now add to the liquid in the cell a piece (about one-fortieth of an inch in diameter) of the double *sulphate of protoxide of iron and ammonia;* stir the solution with the platinum wire, with as little exposure to the air as possible. Cover the cell with a piece of thin glass. The two bands seen previously will have disappeared, and will be replaced by a single intermediate band, fainter but broader than either of the other two, Sp. 2–2, Fig. 466. This is the spectrum of reduced hæmoglobin. The same effect will be produced by a trace of solution of sulphide of ammonium.

The specimen of hæmoglobin thus reduced may be again and again oxidized by exposure to the air and vigorous stirring with the platinum wire. It can be again deoxidized by further addition of the iron salt, or by sulphide of ammonium, if that were previously employed for deoxidation.

This deoxidation and reoxidation of the hæmoglobin is a very characteristic reaction, and serves to distinguish blood from most other substances. If the solution of blood is merely covered with thin glass and kept for some time in the cell, the reduction of the hæmoglobin will be effected spontaneously, and without the addition of any reagents.

A question here may arise whether this spectrum can possibly be due to iron. The question is at once answered by the fact that hydrosulphide of ammonium produces the same result, as also does the tin solution described on page 580, only that it acts more slowly than the iron salt.

3. Add to another portion of the suspected solution, in a cell, a minute fragment of *citric acid,* stirring it thoroughly with a platinum wire. The acid will change the hæmoglobin into hæmatin. If previous to the addition of citric acid the two bands of oxidized hæmoglobin were visible in the green, they will disappear, and if the solution is tolerably strong a faint band will be visible in the red (Sp. 12, Pl. II., and Sp. 3–3, Fig. 466). Add now an excess of ammonia, by dipping the platinum wire into the ammonia solution, and stirring the moistened wire immediately into the liquid in the cell. The band in the red, if present, will now disappear, the original bands either not being at all restored, or only restored to a slight extent. This is a most important change to note, since it shows that the acid has effected a permanent change in the original coloring matter of the blood. Add now to the solution in the cell a very small particle of the double sulphate of iron and ammonia, and cover the liquid over immediately with thin glass. Remove the excess of liquid with blotting-paper, and in order to exclude air it is advisable to fix the glass cover on the cell with gold-size. Turn the cell over and over again, for a few minutes. In cold weather the process of oxidation is slow, and even one-fourth of an hour may elapse before it is complete. By this means the hæmatin will be reduced, and the well-marked Sp. 15, Pl. II., will be seen, having two bands, the one nearest the red being the first to appear, and both being a little more distant from the red than the bands of fresh blood. If the solution be very turbid, the precipitate may be allowed to collect on the side by keeping the tube for a short time in a horizontal position. Preserve and mark the specimen for further examination, if necessary.

By exposing this solution of deoxidized hæmatin to the air, assisted by vigorous stirring, we may often succeed not only in bringing back again the oxidized hæmatin band, but also the bands of oxidized hæmoglobin.

4. Lastly, add to some of the liquid under examination a small quantity of *boric acid.* If the solution be blood, no immediate change will be observed in the position of the bands. The above-mentioned method of examining blood-stains of recent origin requires some modifications in special cases.

Old Blood-stains or Blood-stains on Colored Fabrics.—If blood-stains are old, the coloring matter will probably be found to be scarcely at all acted on with cold water. Either citric acid or ammonia must then be used for dissolving it. If the fabric be white, ammonia should be employed in preference to citric acid; but if it be colored, test, first of all, which of these two reagents has the less action on the dye-coloring matter, and use that one for the purpose of dissolving the blood which acts less on the color of the cloth. To determine this, place a little of the fabric in two watch-glasses and apply a solution of ammonia to one and a solution of citric acid to the other. In general, ammonia should be used in preference to citric acid; but in case of red fabrics ammonia will generally dissolve so much of the dye-stuff that subsequent investigations with the colored solution are rendered much more troublesome and complicated. Hence, if the stain be found on scarlet cloth or other red material, citric acid should be used as the solvent. If the stain be found insoluble both in ammonia and in citric acid, then it should first of all be acted on with ammonia solution and a moderate heat afterward applied.

Proceed then with the solutions in the manner already described, examining them with the spectroscope both before and after deoxidation with the iron salt. The age of a stain does not in general interfere with the spectroscope test, as Mr. Sorby has been able to discover hæmatin with the spectroscope after forty-four years, and others have done the same after thirty years.

The presence of mordants on various materials may necessitate occasional alterations in our proceedings. More particularly will this be the case if the stained fabric has been afterward wetted and the blood by this means to a great extent removed.

What blood remains on the cloth is then very likely to be incorporated with the mordant. In such cases a process such as the following should be adopted: Digest a portion of the stained cloth in dilute ammonia, and afterward squeeze out the liquid. Deoxidize the *thick, turbid, unfiltered solution* in the ordinary manner and examine it for the deoxidized hæmatin bands, using concentrated sunlight, or the lime-light if necessary.

It is to be remembered that in the case we are supposing the hæmatin is probably chemically combined with the mordant; hence filtration, or the allowing the deposit to subside is equivalent to removing most of the blood-coloring matter. The turbidity of the liquid must be overcome in such cases, not by removing the deposit, but by increasing the intensity of the transmitted light.

Examination of Stained Fabrics that have been Washed after Staining, and the Treatment to be Adopted in the Examination of the Water that was used for Washing them.—Hæmatin is a very insoluble body. Probably, therefore, after an article stained with blood has been washed in water, provided a sufficient time has elapsed for the change of the blood-coloring matter into hæmatin to be effected, enough will be left on the stained cloth to produce the spectra necessary for its identification. But it must be remembered that if the stain be perfectly recent, that is, before any of the hæmoglobin is converted into hæmatin, the whole of the blood may then be washed out by rinsing in cold water, and no trace be afterward found on the stained material. Hot water will not effect this removal of the blood like cold water, owing to its further action. Hence, if in a criminal case there is proof that an article has been washed in *cold water,* evidence as to the absence of blood-stains is of little value; while if, after staining, the article was washed in *hot water,* the probability is there will be no difficulty in satisfactorily proving the real character of the stain. In many cases, after a stained fabric has been washed, the blood-stain will be found spread over a considerable surface. Under such circumstances a large piece must be cut out, and digested with a proportionately large quantity of ammonia, or of citric acid solution, the liquid being concentrated afterward by evaporation at a gentle heat.

The water used for washing such materials may have to be examined. This can be done by concentrating the liquid, if necessary, and examining it in the usual manner. If, however, it is found that there is any deposit in the water, it should be carefully collected, acted on with ammonia, and heat applied if the blood be insoluble in the cold solution.

If the recently stained fabric, however, be washed with

soap and water, hæmoglobin will be rapidly converted by the action of the alkali into hæmatin. Soap and water, therefore, really sets the stain, and the probability is that, after washing, there will be little difficulty in detecting it on the fabric itself by the ordinary means. It may be necessary sometimes to examine the soap and water to see if it contains blood. This may be done as follows: Agitate the soap and water with ether, and allow the mixture to stand until the ether has completely separated. Remove the ether with a pipette, and again and again shake the liquid up with ether until the aqueous solution is perfectly clear and free from soap. This liquid must then be concentrated, and examined as usual for blood.

Examination of Stains on Leather.—Blood-stains on leather, or upon any body containing tannic acid, require special management from the precipitation of the coloring matter, which is more or less certain to result. Proceed as follows:

(*a*) Cut off a fine shaving from the stained portion of the leather, so that there may be as much blood and as little leather as possible on the shaving. Bend this shaving so that the side that is stained may be brought into contact with a little water placed in one of the experimental cells, while the leather side of the shaving is not wetted. In this manner solution of the blood will probably be effected, and enough coloring matter obtained for experiment.

Mr. Sorby points out, however, that when a drop of blood falls on leather, the serum soaks into the leather, and leaves the blood-corpuscles on the surface. If the leather be then washed, it would probably be impossible to obtain the blood spectra by the method just described. The following process, recommended by Mr. Sorby, has been found to work satisfactorily:

(*b*) Digest, for a considerable time, a portion of the stained leather in a mixture of one part (by measure) of hydrochloric acid and fifty of water. This will effect a solution of the mixed compound of the blood coloring matter and tannic acid. Pour off the acid liquid, but do not filter it. The solution may appear almost colorless, or of a slightly yellow tint. Add to this an excess of ammonia, when the color will become either a pale purple or a neutral tint, the tint shade being considerably intensified on the addition of the ferrous salt and double tartrate, which are now to be added. The solution is then to be examined in an experimental cell, using a sufficiently intense light, such as the lime-light, or direct sunlight to penetrate the turbid solution. Under these circumstances the spectrum of deoxidized hæmatin will be seen. If the liquid be too turbid to allow even a direct ray from the sun to be passed throught it, allow the cell to remain for a few minutes in a horizontal position, so that a little of the deposit may subside, although if this can possibly be avoided it is desirable to do so, because it will be found that the removal of the deposit at the same time destroys the intensity of the spectrum, proving that the greater part of the hæmatin under these circumstances exists as a compound insoluble in dilute acid.

Before commencing the experiment with the stained portion of the leather, it is advisable to make out clearly how large a piece of the unstained leather may be treated with a given quantity of the acid without producing too dark a solution, and to take care afterward not to employ a larger piece of the stained portion of the leather than is justified by these trial experiments.

Blood-stains on Earth and on Clothes soiled with Earthy Matters.—The stained earth is to be carefully collected and digested in a considerable quantity of ammonia. This is to be poured off, concentrated by evaporation, and the spectroscopic experiments conducted as usual on the turbid solution, an intense light, such as the lime-light, or direct sunlight being used for the purpose, in the manner already described. A similar process should be adopted in examining stained fabrics soiled with earthy matters. This is important to note, inasmuch as the coloring matter in a solution of blood will be found to be completely carried down by earthy matter when shaken up with it.

General Precautions to be Observed in Conducting Microspectroscopic Observations.—We now add a few words of general advice and a few precautions necessary to be observed in examining blood-stains by the spectroscope.

1. If the fabric on which the blood-stain occurs be colored, always examine the spectrum produced by the coloring matter alone, taken from unstained portions of the fabric. Further, it is well to put a little blood on an unstained portion, and, to examine its spectra, when dry, and thus to fully determine, before commencing experiments on the stained portion, any possible interference in the blood spectra resulting from the presence of such coloring matter.

2. On no account decide that an observed spectrum from a suspected stain is due to blood unless it *exactly* coincides with bands produced by a known solution of blood of equal strength treated in a similar manner, and examined side by side. It is advisable to have several tubes of the deoxidized hæmatin of different strengths for purposes of comparison. They are best kept in hermetically sealed tubes, so as to be in readiness whenever they are needed.

3. In all cases examine the spectra both by daylight and by artificial light. We prefer artificial light for general work, but in every case it is advisable to try both means of illumination. Direct concentrated sunlight, or the lime-light should be tried whenever the solution is thick and turbid.

4. Never be content with observing a single spectrum of blood. Remember, further, it is often impossible to obtain the unaltered blood spectrum. Hence, never satisfy yourself that a stain is not blood until you have failed to obtain all the spectra produced by the appropriate reagents.

5. If the liquid under examination be *too strong*, too much light will be cut off by the solution, and the absorption-bands will be in this way obscured. If the solution be *too weak*, the bands will be too faint, and so likely to be overlooked. Practise in this matter to obtain the happy medium. Never (if possible) be satisfied with a single examination.

6. Use extremely minute quantities of the several reagents. Hæmatin produced by an acid is not very soluble in a strong solution of citrate of ammonia. If you add too much protosulphate of iron the precipitate produced so obscures the field as to mask the absorption-bands.

7. Adjust the width of the slit during the spectroscopic examination. All absorption-bands are best defined when the slit is very narrow, while, if the bands are very faint, they will often be best seen at the very moment when the slit is being completely closed.

8. Remember that, with our present knowledge, the spectrum microscope affords no information whatsoever as to whether the blood is from man or beast, nor from what class of animals it is derived; nor, if it be human blood, does it enable us even to hazard a conjecture as to the locality of its origin.

9. Lastly, unless the stain is bright red—an appearance which can only be noted on white or nearly colorless fabrics—never venture an opinion as to the probable age of the stain.

Of the certainty of this method of research, Mr. Sorby says (*Medical Press and Circular*, May 31, 1871), I unhesitatingly say we can distinguish blood (by the micro-spectroscope) from all other animal and vegetable coloring matters.

MICROSCOPICAL EXAMINATION OF BLOOD-STAINS.—Besides the fluid portion of blood certain organized bodies are found, called corpuscles, consisting of two varieties, the white and the red. In the higher animals the red corpuscles are the smaller but the more numerous, while the white corpuscles are rather larger and somewhat granular in structure and of a spherical form. The red corpuscles are circular, biconcave disks, of soft viscid matter, mostly soluble in water, but only very slowly dissolved by serum and the fluid part of the blood. The outer part of the red corpuscles is of firmer consistence than the interior, especially in the older corpuscles, but there is no special envelope or cell-wall. By the action of water the

coloring matter may be dissolved out, leaving the form of the corpuscle but little changed, except that it becomes nearly spherical.

When blood is spread upon glass, or any hard non-porous substance, the corpuscles adhere and retain their diameters unchanged, but when blood dries in a clotted mass, the red corpuscles shrink and often assume a crenated or stellate form.

If the stain to be examined is a mere film on a steel instrument, or other smooth, hard substance, as glass or varnished wood, it may be laid on the stage of the microscope, and with a quarter or one-eighth inch objective, with Beck's patent illuminator above, the light of a lamp may be reflected down through the objective. In this manner the stain may be examined as an opaque object.

By this method the writer has succeeded in recognizing and measuring blood-disks, magnified fourteen hundred diameters, on the blade of a knife which had lain in the forest, covered with leaves, through two winters. Generally blood-stains form a mass too thick to be examined by this method, yet even then the corpuscles contracted to dimensions much below normal may be recognized as blood by this method of examination.

If the stain is in the form of shining scales, or if it is on cloth, leather, or any porous substance, it may be picked off with a needle or pointed instrument, and the dust or particles of clot received upon a glass slide, and moistened with a suitable fluid to separate the corpuscles and restore them to their normal dimensions.

Fluids used in the microscopic examination of blood-corpuscles should be such as will not destroy them, and such as will not increase or decrease their dimensions beyond their normal size. For this purpose a fluid should generally be used having the same specific gravity as blood serum, 1.028 or 1.029.

Robin's fluid consists of distilled water, to which is added chloride of sodium, one per cent., and bichloride of mercury, one-half of one per cent.

Roussin's Fluid. — Glycerine, three parts; sulphuric acid, one part; with water sufficient to reduce the specific gravity to 1.028.

Hayem's fluid consists of distilled water, with the addition of sulphate of sodium, two and a half per cent.; pure chloride of sodium, one-half per cent., and bichloride of mercury, one-fourth per cent.

Professor J. G. Richardson employs water with the addition of common salt, three-fourths of one per cent.

Dr. Thad. S. Up de Graff, who has been very successful in distinguishing the blood of man from that of the lower animals, employs water with bichloride of mercury, one-half of one per cent.

Many other microscopists use glycerine and water, mixed in such proportions as to give a specific gravity of 1.028.

Each of the fluids described has some advantage over the others. The fluids containing bichloride of mercury are not likely to be infested with fungi when specimens are kept for a length of time. Glycerine water interferes less with other tests which may be applied after the microscopic examination is completed, but in this respect it has no advantage over Richardson's salt solution.

Filtered serum from the blood of a frog may be employed in examining stains supposed to be from mammalian blood. Albumen of egg is also sometimes used.

In moistening blood-stains with any fluid whatever it is to be remembered that the substance of the stain absorbing the fluid renders it more dense than it was when prepared; therefore, if the fluid employed has no greater density than blood-serum there is no opportunity for the blood-corpuscles of the stain to enlarge beyond their ordinary dimensions in normal blood.

When a blood-stain is found upon paper more of it remains upon the surface than when the stain is upon cloth, and, after the paper is moistened, the film of blood can sometimes be detached from the surface in small scales or lumps. Mingled somewhat with filaments of the paper, and with molecular material, we find blood-globules more abundant than in stains upon cloth. The form of the globules is also better preserved, and they are often seen in nummular masses, as in fresh blood, and we recognize the central depression and dentate borders characteristic of corpuscles of mammalian blood. These masses also preserve the color which distinguishes blood from all colored objects of vegetable or mineral origin.

Stains upon wood have characteristics similar to stains upon paper.

Stains upon woollen goods are somewhat more difficult to determine than those on cotton, linen, paper, or wood.

If we use the sulphate of soda solution for the examination of fresh stains (not more than six days old) upon iron or steel, the fibrin separates and leaves the corpuscles floating free in the liquid, and the clot shows the characteristic fibrillar arrangement. We find also the white corpuscles either isolated or entangled in the clot. The white corpuscles are no less characteristic than the red by their size, form, finely granular appearance, and nuclei, which appear near the centre, brought into view by the sulphate of soda solution. This solution acts upon the white corpuscles almost as quickly as pure water, but swells them less. The characteristics which distinguish white blood-globules from pus should be noted whenever there is a possibility of finding the two together, which is not common in legal cases.

If blood-stains have been deposited on rusty iron or steel, or have remained long on such instruments even if not rusty, the glycerine solution is much to be preferred in their examination, as it does not act upon the metal; while sulphate of soda or any of the acid solutions cause the deposit of dark granules in the preparation formed of a salt of iron.

The fine dust obtained by scratching a stain with a needle-point or by crushing a large particle picked off from a shining clot, should be covered with a circle of thin glass, and a drop of one of the solutions described above should be allowed to run under the cover. If the stain is recent, it will be in a condition for examination in a few days, or in some cases in a few hours. If the stain is old, over six months, a much longer time is required to soften it. If the object is only to recognize blood-corpuscles when the dust-like particles have been softened, the fluid may be drawn away by touching one side of the cover-glass with blotting-paper, at the same time placing a drop of a staining fluid, as a watery solution of eosine or iodine, on the opposite edge of the cover. After two or three minutes the colored fluid may be withdrawn in the same manner, and salt solution or glycerine water allowed to take its place, when the blood-corpuscles, if any exist, will be easily distinguished, and may be measured by the use of the micrometer.

If the stains are not very recent, provision must be made to prevent evaporation of the fluid used to soften them. Take a glass slide, with a circular excavation in the middle, called a "concave centre," moisten it around the edges of the cavity with glycerine. Thoroughly clean a glass-cover an eighth of an inch or more larger than the excavation, lay it on white paper, moisten the centre with the glycerine solution (sp. gr., 1.028), dropping into the solution so placed the dust obtained from the stain, then invert the slide upon the thin glass-cover in such a manner that the glycerined edges of the cavity on the slide may adhere to the margins of the cover, turn the slide face upward, and examine with the microscope. In the fine dust thus moistened, isolated red and white blood-corpuscles will often be seen immediately. If not, lay the slide face downward on a suitable support, and examine from day to day until the corpuscles become visible and cease to enlarge. They cannot exceed their normal size when treated by this method.

Professor Joseph G. Richardson, M.D., makes a minute dot of glycerine, about the size of this period (•), on a thin glass cover, and pushes into it a particle of suspected blood-clot, the smallest that can be seen by the naked eye, one-thousandth or one-five-hundredth of an inch in diameter, receiving the cover on the concave slide as described above. By this method he obtains a strong solution of the coloring matter of blood, in which the absorption-bands peculiar to blood can be seen, if blood is present in the stain, and by a little practice the bands

may be modified by the addition of sulphuret of sodium, as advised by Preyer and Sorby.

By a similar method, using a little more material on a cover-glass moistened with a very small drop of three-fourths per cent. salt solution, he is able to see, first, the absorption-bands of blood with the micro-spectroscope, then, turning the slide so as to drain off superfluous fluid, and using the microscope with a magnifying power of about two thousand diameters, he is able to see and measure both white and red blood-corpuscles, so as to distinguish human blood from the blood of the ox, pig, horse, or sheep.

In examining a slide prepared by either method above mentioned, if the material is blood, we first observe that the edges of the solid particles gradually become translucent and the fluid around assumes a reddish-yellow color, showing that the coloring matter is soluble. In this condition of the preparation by use of the micro-spectroscope the characteristic absorption-bands of blood will be seen.

After a little time, if the amount of fluid applied be sufficient, the solid particles are softened, and, as they swell up, yellowish-white corpuscles with a slightly granular structure are seen ; these are the well-known white blood-corpuscles, which, with a magnifying power of one thousand diameters or upward, may be distinguished from other organized structures of either animal or vegetable origin. After longer maceration the characteristic red corpuscles of blood, with smooth and sharply defined edges, begin to appear, and after a time are found floating free in the fluid under the cover-glass. If the stain is mammalian blood, some of the corpuscles will be clearly seen as biconcave disks with a light centre and a dark edge or border. If any doubt remains in regard to the nature of these corpuscles, it may generally be resolved by the use of a higher magnifying power. Grains of pollen may be generally distinguished by a roughened edge, or by small points on the surface. Spores of fungi are often found mixed with blood-stains, but in general the texture is different from that of blood. Occasionally the biconcave structure of red blood-corpuscles can be distinguished, as a slight motion causes some of them to roll over as they move across the field. Unicellular algæ, often seen in wet preparations, may be distinguished by the granules which they contain, having a greenish-brown or reddish color. These are grains of chlorophyll. Spores of fungi growing in fluids have generally, if undisturbed, some systematic arrangement not found in the positions assumed by blood-corpuscles.

Erdmann records a case ("Zeitschrift für Analyt. Chemie," ii., 1862, and *Gazette Hebdomadaire*, quoted in *Edinburgh Medical Journal*, October, 1862, page 370) which shows the importance of employing more than one kind of test in examining stains supposed to be blood. "The only trace of an assassination at Leipsic, was a brownish stain found at the spot where the crime had been committed. Under the influence of rain, the stain had assumed the appearance of coagulated blood. An aqueous solution of this stain furnished a reddish fluid, which gave with tannin, with ferrocyanide of potassium, and with Millon's solution,* the same chemical reaction as the aqueous extract of dried blood. Examined under the microscope, the brown matter was found to contain some corpuscles very similar to those of blood. But Erdmann having failed to discover crystals of hæmin, conceived doubts as to the value of the other characters, and repeated with great care the microscopical examination. He then discovered that the bodies supposed to be blood-globules were the spores of algæ called *porphyridium cruentum*, on account of the resemblance of its spores to blood-corpuscles."

This blood-colored gelatinous alga, *porphyridium cruentum*, growing upon moist ground, is of doubtful occurrence in the United States (*Am. Quar. Mic. Journ.*, April, 1879). Thudichum, in "Tenth Report of Med. Officer to Privy Council," 1867, p. 216, mentions a red, gelatinous mass, growing upon a human thigh-bone, which was macerating at St. Thomas' Hospital. The glass vessel in which it was macerating was similarly covered. The microscope showed the red material to consist of minute cells in a gelatinous mass, with which larger green cells were interspersed. The water filtrated from them contained a number of minute bodies in suspension. It was red, and gave a spectrum very similar to blood. The plant in question is called by Thudichum red saprophytes.

Now, if we wash the red corpuscles of mammalia in water, using a tall, narrow jar or a test-tube, allowing them to subside, decanting the supernatant liquid, and adding fresh portions of water until all the coloring matter and viscid part be removed, there will be a whitish precipitate, consisting mostly of pale, thin, nearly transparent, flattened, circular disks. These are the membranous bases or framework of the corpuscles, quite insoluble in water, and so faint as not to be easily seen until their opacity has been increased by corrosive sublimate, iodine, eosine, or some other fluid capable of rendering them opaque. This washed corpuscle is generally finer, smaller, and thinner than the unwashed corpuscle.

The mammalian corpuscle, in its normal condition, is a delicate endosmometer, taking in or giving out fluid according to the relative density of the liquor sanguinis and contents of the corpuscle, allowing rapid variations within certain limits. Accordingly, the corpuscles may be either swollen, puckered, or shrunk into a variety of figures, flat, tumid, like a shallow circular or oval cup, stellate, notched, granulated, mulberry-shaped, crescentic, angular, lanceolate, fusiform, comma-shaped, or possess other figures defying description. In certain of the *cervidæ* the angular, crescentic, and lanceolate corpuscles are abundant. In connection with disease, deformed corpuscles are also found.

The recognition of blood-stains, and the probable determination of the animal from which they came, depends on the use of solvents of the same endosmotic power as the serum of normal blood, and on the microscopic examination and measurement of the corpuscles having the normal form. In the blood of birds, fish, and reptiles having red blood-disks of an oval or ellipsoidal form, it is sometimes possible, when they are standing on end or are distorted by drying, to see them as circular bodies. Time must therefore be allowed for the stains to be fully softened and the corpuscles to be isolated by the solvent before their origin can be decided. There are also some round corpuscles mingled with the elliptical, but they are too few in number to mislead a careful observer.

Stains formed by menstrual blood contain uterine and vaginal mucus mingled with cells of epithelium.

At the commencement of menstruation the linen is stained of a brown color, changing gradually to red. About the third day blood-corpuscles are abundant, mingled with leucocytes and epithelium. The cessation of the courses is marked by the diminution of the red blood-globules and the increase of leucocytes, rendering the flow more nearly purulent. Menstrual blood does not differ from any other blood, except that it is mingled with mucus and epithelium and an abnormal proportion of leucocytes, and that fibrin is almost entirely absent. The absence of fibrin is the most characteristic distinction of menstrual blood.

Blood-stains compared with Stains formed by Lochial Discharges.—Medical experts are often called, especially in cases of infanticide, to distinguish between stains of blood and those formed by the lochiæ. These stains are to be examined by the same methods as are available for stains of normal blood. In the lochial discharge, about six hours after delivery, we find about five leucocytes to one hundred red blood-corpuscles. At the end of the first day only about one-third of the organized structures are red blood-corpuscles. The leucocytes are nearly equal in number to the red corpuscles ; pavement epithelium from the vagina is also abundant. Among the cells are some spheroidal or somewhat polyhedral by recipro-

* Millon's solution is a strongly acid (nitric and nitrous) solution of proto- and per-nitrate of mercury, made by dissolving metallic mercury in its weight of strong nitric acid with the aid of heat (Micrographic Dictionary).

cal pressure, united in groups similar to the deeper layers of epithelium of the vagina or neck of the uterus. The liquid, more or less viscous and odorous, which holds these elements in suspension, is studded with grayish granules. On the second day the leucocytes increase in number and the red globules diminish, and little by little the lochia assumes a russet tint, which on the third or fourth day passes into a grayish white or yellow.

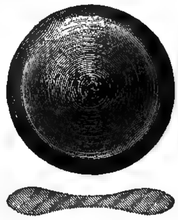


FIG. 467.

From the fifth to the seventh day, varying in different subjects, the red corpuscles almost entirely disappear, and the leucocytes become decidedly granular. Pavement epithelium is still found, but less abundantly than during the preceding days. The epithelial scales are generally imbricated, coming off in patches. The gray molecules become more adhesive and abundant, and the fat granules diminish in number. Fibro-plastic fusiform bodies without a nucleus, pale and transparent, are also found. This

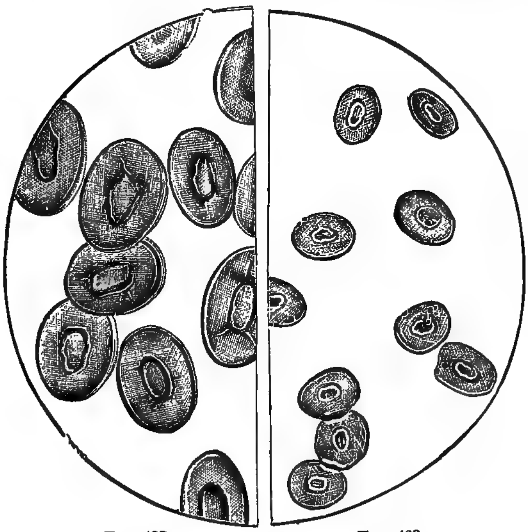


FIG. 468. FIG. 469.

composition of the lochia continues without much change until the close of the flow. By these characteristics

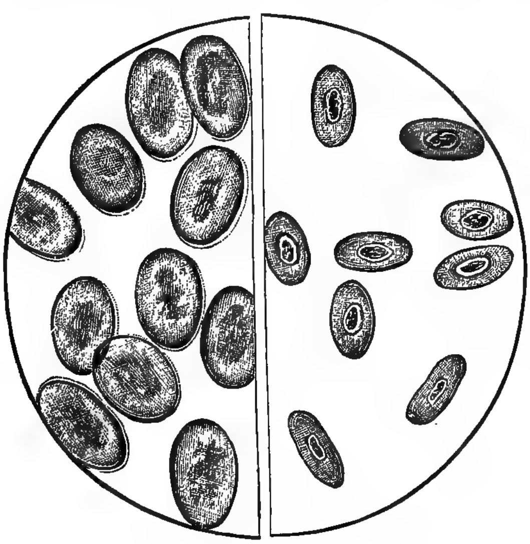


FIG. 470. FIG. 471.

stains of lochial discharges can generally be distinguished from normal blood.

In Fig. 467 is shown the appearance of the red corpuscle of human blood as seen in the microscope, when magnified twenty-five hundred diameters. When lying flat the border appears as a dark ring, which corresponds

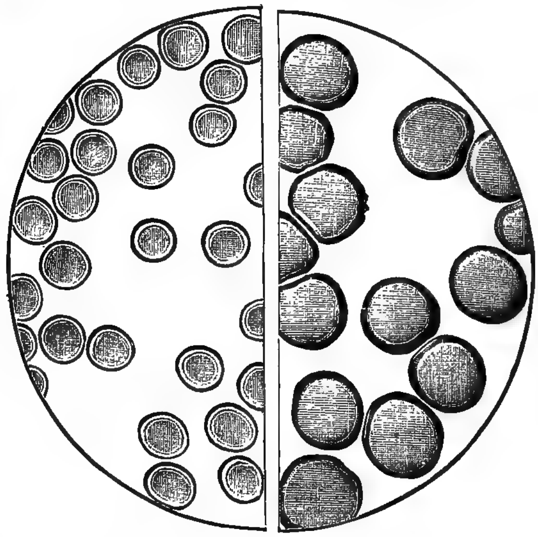


FIG. 472. FIG. 473.

to the thickened extremities shown in the lower figure, in which the corpuscle is viewed edgewise. This dark border of the red corpuscle varies from one-fiftieth to one-thirtieth of the diameter of the corpuscle, and should always be measured as a part of the corpuscle, as can easily be demonstrated by examination of a glass disk made so as to have a section such as is shown for the corpuscle

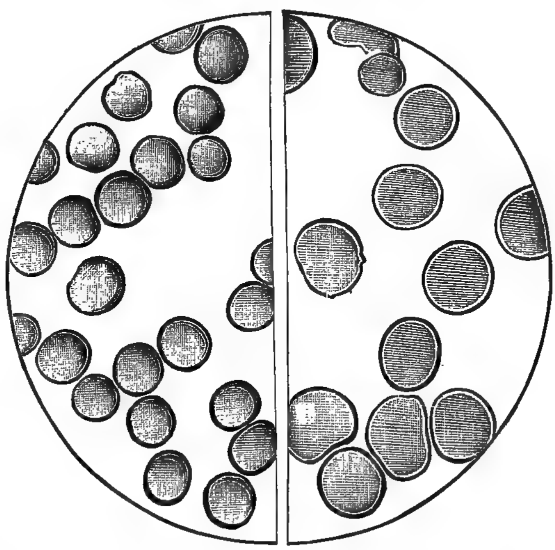


FIG. 474. FIG. 475.

in Fig. 467. Fig. 468 shows the form of the red corpuscle in the blood of a snake, and Fig. 469 the blood of a fish (the pickerel). These corpuscles are elliptical with a nucleus. Fig. 470 shows the blood of the common fowl, and Fig. 471 the blood-corpuscles of the ruffle-grouse.

These figures show that the blood-corpuscles of reptiles, fishes, and birds are easily distinguished by their form and by their nucleated structure from the blood of the higher animals and man; as the red blood-corpuscles of

man and all the mammalia, except the camel tribe, are circular and destitute of nuclei. Fig. 472 shows the blood of a sheep, and Fig. 473 the blood of a man, both being accurate copies of a photograph of the two kinds of blood spread side by side upon the same glass plate, and magnified by the microscope about nine hundred and fifty diameters. Fig. 474 and Fig. 475 are copies similarly

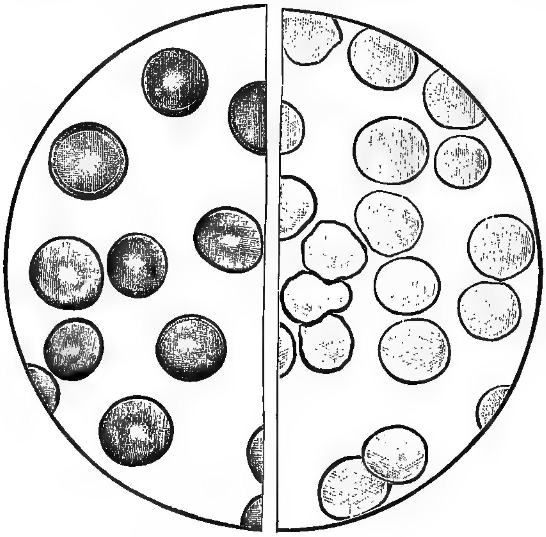


FIG. 476. FIG. 477.

made from photographs of the blood of the ox and man, spread side by side and photographed together. Fig. 476 shows human blood spread upon the same glass slide with Fig. 477, dog's blood. Here the corpuscles are shown so nearly alike, that they can be distinguished only by most careful measurement, and even then the distinction is not so clear as to be generally acknowledged. Figs. 476 and

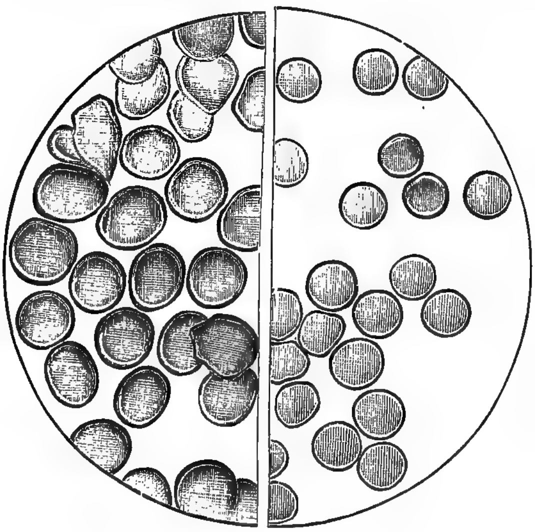


FIG. 478. FIG. 479.

477 show the great difficulty of distinguishing the blood of man from the blood of some other animals.

Fig. 478 is from a photograph of the blood of a gray squirrel, and Fig. 479 from the blood of a cat similarly magnified, but not spread upon the same slide.

Fig. 480 shows the blood of man compared with Fig. 481, the blood of the Guinea-pig. These were photographed with the same magnifying power on different slides. They show very clearly the difficulty of distinguishing the blood of man from that of the Guinea-pig.

Fig. 482 is from a photograph of the blood of a rabbit, with the same enlargement as in the preceding figures.

Fig. 483 is taken from a photograph of the blood of a human embryo weighing only one hundred and forty-

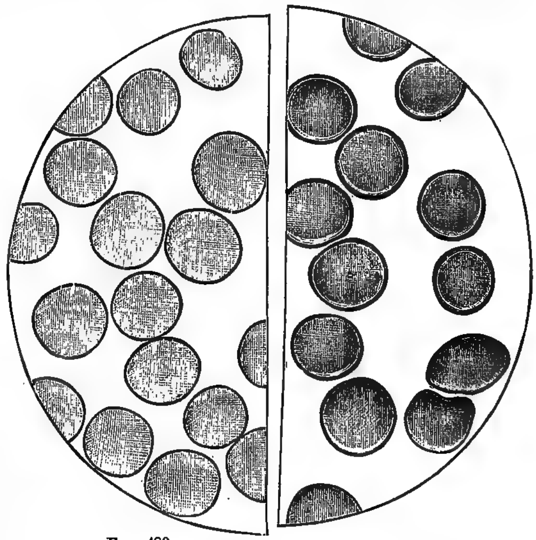


FIG. 480. FIG. 481.

three grains. It shows red corpuscles similar in size and appearance to those of adult human blood, also globulins and giant red blood-corpuscles without nuclei. It also shows large nucleated corpuscles, the nuclei being similar in form and appearance to those of red corpuscles found in the adult. The giant corpuscles are seldom seen except in the blood of the newly born.

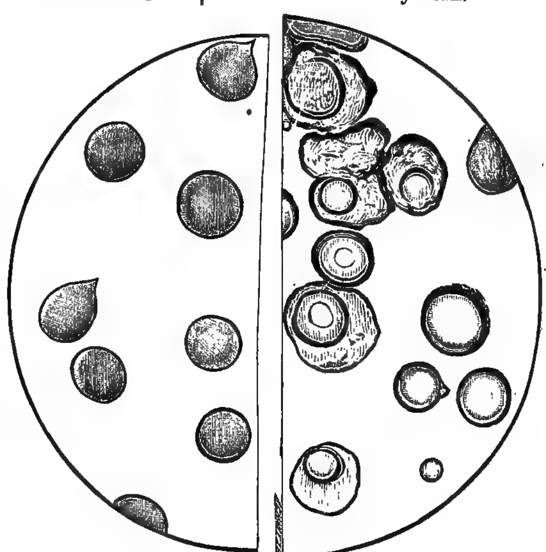


FIG. 482. FIG. 483.

From the foregoing illustrations, it is evident that any attempt to distinguish human blood from the blood of reptiles, fishes, and birds, will be comparatively easy, as the forms are different; but in the case of the higher animals the distinction, where any distinction is possible, must depend on careful measurement of the corpuscles.

In any specimen of blood we find corpuscles of vary-

Blood-Stains.

ing size, but a remarkable uniformity in the average measurements of blood from animals of the same kind.

Some discrepancies appear in the tables of measurements of blood as given by different authors. The tables found in most works on physiology or on medical jurisprudence were made when the instruments employed and micrometers used were by no means as perfect as the microscopes and micrometers now available. The following table has been prepared with great care. The measurements, with two or three exceptions, were made by J. B. Treadwell, M.D., with a $\frac{1}{25}$-inch objective, magnifying about two thousand five hundred diameters linear, and a glass micrometer placed in the eyepiece. The blood was spread upon glass and quickly dried. The reduction and arrangement of the results as given in the table were performed by the writer of this article. The standard of measurement was a micrometer ruled by Professor W. A. Rogers, of Cambridge, Mass., and carefully compared with the standards procured at great expense by the United States Government.

MEASUREMENTS OF MAMMALIAN BLOOD.

Source of blood.	Number of corpuscles measured.	Mean diameter.	Minimum and Maximum.	Range of averages by tens.	Range by twenties.	Range by fifties.	Range by hundreds.	Range by two hundreds.
Five men, ages 23 to 49 years	1,000	7,941	5,773 9,394	7,697 8,152	7,782 8,110	7,845 8,061	7,884 8,046	7,902 7,983
Five women, 18 to 55 years	1,000	7,927	6,350 9,287	7,825 8,152	7,787 8,026	7,873 7,993	7,901 7,968	7,913 7,950
3 infants at birth, 1 male, 2 females ..	600	7,950	4,233 10,160	7,667 8,298	7,716 8,100	7,833 8,031	7,918 7,983	7,988 7,970
Boy, 8 years old....	200	7,983	6,929 9,160	7,747 8,282	7,828 8,191	7,891 8,079	7,965 8,000	7,983 .....
Man, 70 years old ..	200	7,916	7,005 9,236	7,658 8,121	7,662 8,105	7,768 8,028	7,852 7,980	7,916 .....
Fifteen persons, as above..............	3,000	7,938	4,233 10,160	7,658 8,298	7,662 8,191	7,768 8,079	7,852 8,046	7,913 7,983
Blood-stains (human) restored....	1,000	7,910	5,570 9,687	7,700 8,189	7,723 8,010	....	....	....
25 dogs	2,500	6,918	4,618 8,931	6,138 7,352	6,445 7,305	6,523 7,258	6,673 7,198	....
Guinea-pig, male, 3 months...........	200	7,476	5,849 8,390	7,231 8,698	7,309 7,659	7,249 7,684	7,398 7,559	....
Woodchuck, female	200	7,280	5,387 8,467	7,043 7,528	7,112 7,374	7,215 7,351	7,279 7,282	....
Muskrat, male	200	7,283	6,158 9,391	6,920 7,535	7,120 7,555	7,195 7,428	7,245 7,320	....
2 rabbits, 1 white, 1 mixed...........	400	6,365	4,618 8,082	6,196 6,596	6,227 6,485	6,294 6,409	6,349 6,383	6,354 6,377
2 hares, 1 male, 1 female	400	5,764	4,618 7,120	5,367 6,080	5,377 6,049	5,604 5,863	5,733 5,779	5,756 5,772
Gray squirrel, 1 female, 1 male, 5 mos.	400	6,876	5,926 7,851	6,366 7,436	6,627 7,079	6,774 7,080	6,823 7,004	6,827 6,926
Red squirrel, female, 5 months ..	200	6,607	4,926 8,313	6,227 6,851	6,381 6,897	6,496 6,709	6,592 6,622	....
Striped squirrel, female	200	6,753	5,387 7,697	6,573 6,981	6,647 6,901	6,701 6,815	6,747 6,758	....
Red fox, male, 5 months...........	200	6,482	5,541 7,312	6,250 6,674	6,408 6,562	6,474 6,544	6,470 6,494	....
Pig, 2 of 3 months, 1 of 2 weeks	600	6,101	3,849 8,391	5,418 6,520	5,757 6,466	5,880 6,246	6,028 6,169	6,069 6,144
Ox, 3 male, 2 female (one 1 day, one 3 months)..........	1,000	5,436	3,916 6,774	5,150 5,703	5,296 5,622	5,345 5,543	5,347 5,482	5,406 5,461
Horse, 10 years.....	200	5,508	4,618 6,774	5,208 5,818	5,257 5,633	5,473 5,553	5,493 5,513	....
Ass, 1 male, 1 female	400	6,293	5,003 7,697	6,018 6,566	6,138 6,539	6,201 6,377	6,219 6,376	6,259 6,326
Mule, 6 years.......	200	5,421	3,464 6,312	5,280 5,680	5,327 5,545	5,377 5,472	5,419 5,424	....
Cat, 1 adult, 1 kitten, 3 weeks......	400	5,463	2,617 6,774	4,311 5,780	4,361 5,676	5,268 5,573	5,419 5,522	5,431 5,495
Sheep, male, 15 days; female, 1 year....	400	4,745	3,079 6,774	4,503 4,972	4,588 4,869	4,665 4,785	4,725 4,764	4,744 4,746
Goat, 1 male, 1 female..............	400	3,567	2,617 4,080	3,394 4,764	3,401 3,710	3,467 3,693	3,535 3,638	3,546 3,587
Mouse, house, common	200	6,038	2,309 7,004	5,772 6,281	5,891 6,200	5,990 6,094	6,087 6,039	....
Mouse, house, long-tailed.............	200	6,099	4,618 6,696	5,857 6,258	5,968 6,208	6,063 6,143	6,089 6,109	....
Mouse, field	200	5,095	4,080 6,928	5,733 6,041	5,803 5,995	5,814 5,967	5,891 5,919	....
Rat, male	200	6,500	3,079 8,005	6,289 6,820	6,346 6,695	6,441 6,694	6,490 6,510	....
Mole, male	200	6,216	4,618 7,697	6,095 6,435	6,080 6,339	6,131 6,293	6,175 6,258	....
*Elephant	100	9,259	7,164 11,504	....	....	....	9,259	....
Woman, 19 years, anæmia	100	7,346	3,464 9,237	6,674 7,605	7,012 7,628	7,177 7,515	7,346	....
Child, 6 weeks old, starved to death .	100	7,573	4,465 8,636	7,328 7,712	7,498 7,639	7,572 7,574	7,573	....
*Human embryo, 143 grains, non-nucleated corpuscles...	20	11,346	9,736 13,486	11,032 11,661	11,346	....	....	....
*Human embryo, nuclei of nucleated disks........	10	8,089	5,394 11,611	8,089	....	....	....	....
A male cat, stupefied five hours by alcohol.............	100	5,489	4,772 7,235	5,327 5,680	5,426 5,846	5,479 5,498	5,489	....

* Measured by M. C. White.

In the measurements given in this table the whole of the dark border shown in Fig. 467 was measured. The measurements were originally taken and recorded in parts of the American standard inch which has been reduced to parts of a millimetre by reckoning 1 inch = 25.40098 millimetres. The measurements in the table are given in millionths of a millimetre.

To secure a fair average two hundred corpuscles were generally measured, and often this number were measured from several animals of the same class. To show how large a number of corpuscles should be measured to obtain a fair average, the range of averages are given as computed by tens, twenties, fifties, and hundreds; also the range of averages of two hundreds as taken from separate animals.

TABLE SHOWING DISTRIBUTION OF VARIOUS SIZES OF BLOOD-CORPUSCLES MEASURED IN PARTS OF AN INCH. (BY DR. J. B. TREADWELL.) *

Fractions of an inch.	Man.	Dog.	Pig.	Ox.	Sheep.	Goat.
1-2700	2	......	......	......	......	......
1-2800	6	......	......	......	......	......
1-2900	14	......	......	......	......	......
1-3000	32	......	......	......	......	......
1-3100	33	......	......	......	......	......
1-3200	46	6	......	......	......	......
1-3300	37	17	......	......	......	......
1-3400	14	23	2	......	......	......
1-3500	9	24	2	......	......	......
1-3600	4	58	4	......	......	......
1-3700	1	23	17	......	......	......
1-3800	2	12	21	1	......	......
1-3900	......	10	9	3	......	......
1-4000	......	9	31	1	......	......
1-4100	......	12	34	22	......	......
1-4200	......	3	15	16	......	......
1 4300	......	1	7	7	......	......
1-4400	......	2	11	10	......	......
1-4500	......	......	9	17	......	......
1-4600	......	......	8	15	2	......
1-4700	......	......	18	51	15	......
1-4800	......	......	4	15	8	......
1-4900	......	......	4	1	6	......
1-5000	......	......	1	9	19	......
1-5100	......	......	2	8	11	......
1-5200	......	......	0	3	20	......
1-5300	......	......	0	5	17	......
1-5400	......	......	0	3	30	......
1-5500	......	......	1	13	47	......
1-5600	......	......	......	.....	11	......
1-5700	......	......	......	......	3	......
1-5800	......	......	......	......	6	3
1-5900	......	......	......	......	1	0
1 6000	......	......	......	......	0	2
1-6100	......	......	......	......	0	2
1-6200	......	......	......	......	0	4
1-6300	......	......	......	......	2	5
1-6400	......	......	......	......	1	30
1-6500	......	......	......	......	0	0
1-6600	......	......	......	......	1	45
1-6700	......	......	......	......	......	20
1-6800	......	......	......	......	......	29
1 6900	......	......	......	......	......	0
1-7000	......	......	......	......	......	15
1-7100	......	......	......	......	......	17
1-7200	......	......	......	......	......	0
1-7300	......	......	......	......	......	15
1-7400	......	......	......	......	......	0
1-7500	......	......	......	......	......	4
1-7600	......	......	......	......	......	4
1-7700	......	......	......	......	......	0
1-7800	......	......	......	......	......	1
1-7900	......	......	......	......	......	0
1-8000	......	......	......	......	......	4
No. of corpuscles.	200	200	200	200	200	200
Maximum	1-2727	1-3203	1-3473	1-3837	1-4647	1-5892
Minimum........	1-3870	1-4400	1-5500	1-5500	1-6600	1-8048
Mean..........	1-3197	1-3657	1-4227	1-4654	1-6204	1-6839

J. G. Richardson, M.D., of Philadelphia, during the progress of the Centennial Exhibition at Philadelphia, measured one hundred corpuscles from each of fourteen men of different nationalities, using a one-twenty-fifth inch immersion objective and a cobweb micrometer eyepiece, the microscope thus arranged magnifying 1,800 diameters. He found the average diameter of the fourteen hundred corpuscles to be 1-3224 inch, or 0.007879 mm. This is smaller than the measurement given in the

* The number of corpuscles include all found between the fraction opposite to which they are placed and the next succeeding fraction of an inch.

table, 0.007938 mm. I am informed by Dr. Richardson that he measured from the outside of the dark border of the corpuscle on one side to the inner side of the dark border on the opposite side of the corpuscle. If we add one-fiftieth of the diameter for the remainder of the dark border we should obtain 0.008036 mm., which is a trifle larger than the average given in the table. This difference may possibly be attributed to minute differences in the micrometers used, or it may be owing to what is known as the personal equation of the observer.

Professor Wormley, of the University of Pennsylvania, whose extensive and valuable measurements of blood-corpuscles are published in the second edition of his work on "Micro-chemistry of Poisons," measured the whole of the dark border of the corpuscle. Professor Wormley used a one-tenth inch objective made by Beck, and a one-thirty-second inch objective made by Gundlach, magnifying from 1,150 to 2,300 diameters. In the following table the measurements of Treadwell and Wormley are compared with the measurements made by Gulliver twenty-five years ago, and published by him in the "Proceedings of the Zoölogical Society of London" in 1875.

AVERAGE SIZE OF RED BLOOD-CORPUSCLES, IN FRACTIONS OF AN INCH.

MAMMALS.	By Gulliver.	By Wormley.	By Treadwell.
Man	1-3200	1-3250	1-3200
Monkey	1-3412	1-3382	......
Opossum	1-3557	1-3145	......
Guinea-pig	1-3538	1-3223	1-3397
Kangaroo	1-3440	1-3410	......
Muskrat	1-3550	1-3282	1-3487
Dog	1-3532	1-3561	1-3672
Rabbit	1-3607	1-3653	1-3984
Rat	1-3754	1-3652	1-3908
Mouse	1-3814	1-3743	1-4223
Pig	1-4230	1-4268	1-4163
Ox	1-4267	1-4219	1-4673
Horse	1-4600	1-4243	1-4614
Cat	1-4404	1-4372	1-4648
Elk	1-3938	1-4384	......
Buffalo	1-4586	1-4351	......
Wolf (prairie)	1-3600	1-3422	......
Bear (black)	1-3693	1-3656	......
Hyena	1-3735	1-3644	......
Squirrel (red)	1-4000	1-4140	1-3847
Squirrel (gray)	......	......	1-3322
Ground squirrel (striped), chipmunk	......	1-4200	1-3762
Raccoon	1-3950	1-4084	......
Elephant	1-2745	1-2738	......
Leopard	1-4319	1-4390	......
Hippopotamus	1-3429	1-3560	......
Rhinoceros	1-3765	1-3649	......
Tapir	1-4000	1-4175	......
Lion	1-4322	1-4143	......
Ocelot	1-4220	1-3885	......
Mule	......	1-3760	1-4432
Ass	14-000	1-3620	1-4036
Bat	14-175	1-3966	......
Sheep	15-300	1-4912	1-5353
Ibex	......	1 6445	......
Goat	1-6366	1-6189	1-7982
Sloth	1-2865	......	......
Platypus (duck-billed)	1-3000	......	......
Whale	1-3099	......	......
Capybara	1-3190	1-3164	......
Seal	1-3281	......	......
Woodchuck	1-3484	......	1-3489
Musk-deer	1-12325	......	......
Beaver	1-3325	......	......
Porcupine	1-3369	......	......
Llama { Long diam	1-3361	1-3201	......
Llama { Short diam	1-6229	1-6408	......
Camel { Long diam	1-3123	1-3331	......
Camel { Short diam	1-5876	1-5280	......
Red Fox	......	......	1-3918

	Gulliver.		Wormley.	
	Length.	Breadth.	Length.	Breadth.
BIRDS.				
Chicken	1-2102	1-3466	1-2080	1-3483
Turkey	1-2045	1-3598	1-1894	1-3444
Duck	1-1937	1-3424	1-1955	1-3504
Pigeon	1-1973	1-3643	1-1892	1-3804
Goose	1-1836	1-3839	......	......
Quail	1-2347	1-3470	......	......
Dove	1-2005	1-3369	......	......
Sparrow	1-2140	1-3500	......	......
Owl	1-1763	1-4076	......	......

	Gulliver.		Wormley.	
	Length.	Breadth.	Length.	Breadth.
REPTILES.				
Tortoise (land)	1-1252	1-2216	1-1250	1-2200
Turtle (green)	1-1231	1-1882	......	......
Boa Constrictor	1-1440	1-2400	1-1245	1-2538
Viper	1-1274	1-1800	......	......
Lizard	1-1555	1-2743	......	......
BATRACHIANS.				
Frog	1-1108	1-1821	1-1089	1-1801
Toad	1-1043	1-2000	......	......
Triton	1-848	1-1280	......	......
Proteus	1-400	1-727	......	......
Amphiuma tridactylum	1-363	1-615	1-358	1-622
FISHES.				
Trout	1-1524	12-460	......	......
Perch	1-2099	12-824	......	......
Pike	1-2000	13-555	......	......
Eel	1-1745	12-842	......	......
Lamprey	Circular.	12-134	......	......
Nucleus	......	16-400	......	......

From these tables it is clearly shown that there is no danger that a careful microscopist would ever mistake the blood of a goat, sheep, horse, ox, or pig for the blood of a human being; or that of any animal having blood-corpuscles with an average diameter less than $\frac{1}{4000}$ of an inch or 0.0063 millimetre.

Concerning the possibility of distinguishing the blood of a dog from that of man medical experts are in nowise agreed, a few contending that they can distinguish a recent stain of the blood of a dog from the blood of man, and they have successfully accomplished the task when put to the crucial test of experiment.

The late Col. J. J. Woodward, M.D., when testifying as an expert in the Hayden trial, at New Haven, Ct., in 1879, stated that he had measured twenty corpuscles from a young dog, forty from another, and fifty from a third, in which he found the averages of the corpuscles measured from each one of those dogs larger than the recognized average size of human blood-corpuscles. In regard to these measurements Dr. Woodward stated in his cross-examination by the State, "*I looked to find big corpuscles, and I knew that the group around them would be large.*" The same expert has published measurements of the blood of other dogs so large that he inferred that there is no safety in attempting to state positively that a given stain is the blood of man and that it could not be the blood of a dog.

L. Perier has shown that the blood of new-born infants often contains giant corpuscles similar to the large non-nucleated corpuscles of the human embryo, and states that until recently these have not been considered as true red corpuscles.

He also states that these giant corpuscles have a tendency to collect together, and that in estimating average measurements it is important to examine all parts of the slide on which the blood is spread. L. Perier also says that he finds in the blood of infants many globulins nearly spherical, only about half the diameter of ordinary blood-disks. If these globulins are not included in the measurement it will be easy to obtain large averages for the blood of infants.

Dr. R. U. Piper, of Chicago, finds that the blood-corpuscles of new-born infants retain much of the character of pre-natal blood, and give average diameters larger than the blood of adults. He also finds the blood of young puppies giving larger average diameters than that of the blood of adult dogs, but these facts do not disparage the value of the microscope as a means of distinguishing the blood of man from that of full-grown dogs, especially if we can obtain for comparison authentic specimens of the blood of the particular man and dog with which a given blood-stain is to be compared in a given case.

Dr. Thad. S. Up De Graff (in *The Microscope*, October, 1883), states that the red blood-corpuscle of the dog resists the action of water and ruptures less readily than the red corpuscle of human blood, because, as he thinks,

the cell-wall or border is thicker in dog's blood than in human blood.

By a careful study of the micrometric data from which the table of measurements on page 587 was calculated, I find as a general rule (to which there are some exceptions) that the blood-corpuscles of young animals have a greater range (as Perier and Hayem have stated) from the smallest to the largest corpuscle, and a slightly greater average diameter than the blood of adults. The same is apparently true of the blood of females as compared with the blood of males. My own measurements of human blood of infants and adults, both male and female, tends to the same conclusion.

Since the death of my esteemed friend, J. B. Treadwell, M.D., to whose labors I am indebted for the photographs from which the figures of blood-corpuscles in this article were copied, and for the measurements of blood-corpuscles used in the table on page 587, I find among his papers, given me by his request, a discussion of the large averages claimed by some observers in the blood of some adult dogs. A slide in my possession, prepared by Dr. Treadwell, shows the blood of a cocker spaniel, with a peculiar irregularity in the distribution of the corpuscles, which are arranged in bands. Large corpuscles are found in one band, and in an adjoining band smaller corpuscles are gathered together; an effect which is evidently due to the slightly uneven surface of the glass slide. I have three photographs, taken from different parts of this slide, numbered 162, 163, and 164, one of which (No. 164) shows the large and small corpuscles very uniformly intermingled. The other two photographs, Nos. 162 and 163, from the same slide, show the large and small corpuscles separated by spreading.

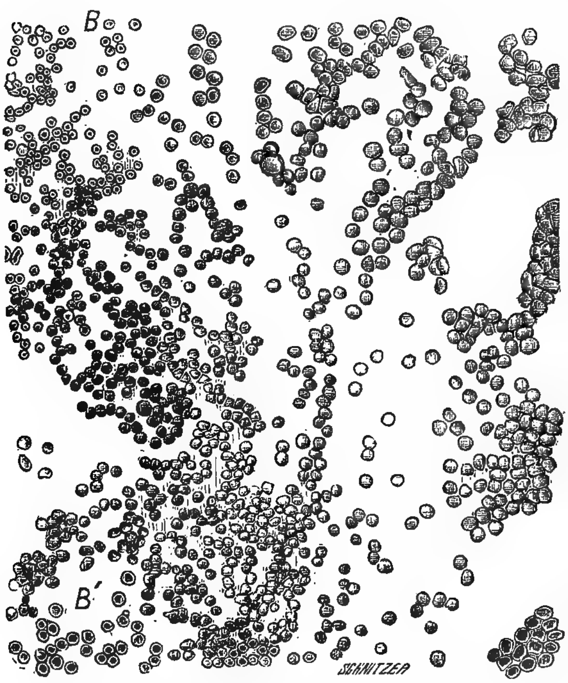


FIG. 484.

Fig. 484 has been copied from Negative 163. The band *B B′* shows the smaller corpuscles, separated from the large corpuscles by a space in which they are less numerous. This figure shows how different averages may be obtained from the same slide, as is more fully explained below.

The following is Dr. Treadwell's statement of measurements taken in the three fields photographed, the negatives being numbered 162, 163, and 164. One hundred and fifty corpuscles were measured from each field, and are recorded in fractions of an inch.

The following table shows the results of measuring different parts of the same slide :

Negative.	Band of large corpuscles.				Band of small corpuscles.				Results of whole number of measurements.			
	No.	Max.	Min.	Mean.	No.	Max.	Min.	Mean.	No.	Max.	Min.	Mean.
162........	75	1-2750	1-3666	1-3300	75	1-3300	1-4647	1-4083	150	1-2750	1-4647	1-3654
163........	75	1-3000	1-4024	1-3336	75	1-3267	1-5238	1-4069	150	1-3000	1-5238	1-3667
164........	..	.....	.....	.....	..	.....	.....	.....	150	1-2844	1-4852	1-3654

The writer of this article has himself measured one hundred corpuscles from the slide copied in Fig. 484. Fifty corpuscles from the band *B B′*, Fig. 484, give an average diameter of 1-4511 of an inch; and fifty corpuscles from the part of the slide shown in the right side of Fig. 484 average 1-3086 of an inch. The average of all these corpuscles combined is 1-3665 of an inch. These measurements were made with a cobweb micrometer and a $\frac{1}{16}$ inch objective magnifying 1,500 diameters.

The illustrations here given show the necessity of examining all parts of the slide when measuring blood-corpuscles. In this work a mechanical movement of the stage of the microscope aids in securing a proper survey of the entire field.

So far as the writer has been able to ascertain, all the large averages in the measurement of the blood of dogs, which have been published to show the uncertainty of distinguishing between the blood of man and the blood of the dog, have been based upon the measurement of blood spread upon glass and quickly dried. Hayem's observations of large corpuscles collecting together, may be repeated by placing a drop of blood on the under-side of a thin glass-cover over a moist cell, but the results obtainable by that method can hardly mislead a careful observer.

When blood-stains are examined, the corpuscles are generally examined in the moist condition, and no irregular spreading or automatic collection of large corpuscles is likely to interfere with fair and normal average measurements.

While the blood-corpuscles of the dog are much nearer the size of human blood than are the corpuscles of the sheep, horse, ox, and pig, still the difference is such that the blood of man and the blood of a dog may be distinguished with, at least, a considerable degree of probability, as indicated by our tables and by the double photograph shown in Figs. 476 and 477.

In conclusion, it seems proper to say that the medical expert can safely and positively decide that a given stain is blood; that it is not the blood of a fish, reptile, or bird; that it is the blood of one of the class mammalia, and that from the measurement of the corpuscles he finds it correspond closely with human blood, as distinguished from that of most domestic animals; or in other cases, that he finds it cannot be human blood, but that it corresponds with the blood of some other animal which it is claimed to be. Such testimony often serves to convict the guilty by refuting a fictitious plea, or clear the innocent beyond a doubt when other circumstances appear against him.

Moses C. White.

BLOOD-VESSELS. The blood-vessels are the connecting series of tubes which, commencing at the heart and terminating again at the heart, complete the circle of the circulatory system. These vessels are divided into three sets, the arteries, or efferent vessels, by which the blood is conducted away from the heart; the veins, or afferent vessels, by which the blood is returned to the heart; and the capillaries, small, hair-like vessels, which form the connection between the arteries and veins.

The blood-vessels are arranged in two distinct systems, one connecting the right ventricle of the heart with the left auricle, known as the pulmonary system, because it is for the most part situated within the lungs; the other, connecting the left ventricle with the right auricle, known as the systemic system, because it is situated in the body in general.

Each system of vessels commences by a single artery of large calibre—the pulmonary artery for the pulmonary circulation, and the aorta for the systemic circulation. As these arteries proceed, they give off branches, usually at an acute angle, though sometimes at an obtuse or even a right angle, and these branches, after further division and subdivision, and gradual change of structure, merge into the capillaries.

After continuing as capillaries for a short distance they unite and form venous radicles, which by further union become the large veins which pour the blood into the heart.

The transition of the arteries into the capillaries, and of the capillaries into the veins, is a gradual one.

After the division of an artery into two branches, it is found that while the capacity of either branch is less than that of the parent trunk, that of both divisions is greater, so that, as the blood-vessels grow smaller, the capacity of the circulatory system becomes greater, and by the time the capillaries are reached it is estimated that the capacity of the blood-vessels has increased five hundred to eight hundred times over that of the aorta at its commencement.

As the veins grow larger by union with each other, the capacity of the circulatory system again grows less, so that at the entry of the large veins (the venæ cavæ), into the heart their capacity approaches that of the aorta, although it is not so small.

This does not hold good in the pulmonary system, as the capacity of the pulmonary veins is the same as that of the pulmonary artery. The entire system of blood-vessels may be represented by two truncated cones placed base to base, one an arterial cone, the other a venous cone, each having its apex at the heart and its base at the capillaries.

The blood-vessels possess—arteries, veins, and capillaries alike — a foundation groundwork of tissue to which the remaining structures which go to make up a blood-vessel are added. Much as the latter may vary in the different kinds of vessels, this groundwork remains the same, and is continuous throughout the vascular system. This basis-tissue, which is known as the "endothelial tube" (His), the "periepithelial tube" (Auerbach), the "cell membrane" (Remak), is composed of delicate, flattened, more or less fusiform or polygonal cells, composed each of a nucleus with surrounding protoplasm, and arranged for the most part parallel to the long axis of the vessel. To this protoplasmic tube, which forms the sole constituent of the finest capillaries, structures of different kinds in the form of a series of "investing" or "vascular" membranes are added, to make, in the one instance, an artery, or in the other a vein.

Arteries (αηρ, air), so called because, being found empty after death, they were supposed by the ancients to be filled with air, are the efferent vessels of the circulatory system and form that portion of the chain of blood-vessels which extends from the heart to the capillaries. They are cylindrical tubes.

The course of an artery to an organ is usually a direct one, although in some cases it is markedly tortuous. Arteries are usually single, and are accompanied by one, two, or more veins, known as "venæ comites," by nerves and by lymphatics. They are covered by a sheath of connective-tissue, which acts as a protective and holds them in position.

Although the chief blood-supply of an organ is through a single artery, the connections of this artery with others are usually sufficiently numerous to convey blood to the part in case the main supply is cut off. The connection of one blood-vessel with another is termed anastomosis or inosculation, and by means of it collateral circulation is established.

Some arteries have no anastomoses, so that, if by any means they become occluded, the circulation of the part to which they are distributed can rarely be re-established, or if at all but slowly and through their capillary connections. Such arteries are denominated "terminal arteries." Examples of this variety are found in the kidney, the lungs, the spleen, and the brain.

The proportionate relations between the thickness of the arterial walls and the diameter of the lumen of the vessel vary much in the different arteries.

Peculiar arteries are those of the brain, in that they have very thin walls and a large lumen, and further, they are surrounded by lymphatic sheaths known as perivascular canals.

The longest artery in the body is the spermatic, the shortest is the anterior communicating.

An artery has three coats. These coats are denominated, according to their position, external (tunica adventitia), middle (tunica media), and internal (tunica intima); an arbitrary division, however, as each coat is capable of further separation into well-recognized layers.

The divisions of the internal coat are three. Of these, the one next to the blood-current is formed of smooth and flat cells which enter into the formation of the common "endothelial tube;" outside of this is a layer of finely fibrillated connective-tissue with a number of branched corpuscles lying in the cell spaces of the tissue forming the "subepithelial layer," the "intermediary layer," or the "striated layer of the internal coat" (Kölliker).

The third division of the internal coat, the "internal elastic lamina" (membrana elastica intimæ) is sometimes described as a portion of the middle coat, and appears under the microscope as a wavy line which refracts light strongly, and does not stain with the ordinary coloring materials. It is composed of laminæ of perforated yellow elastic tissue, known as the fenestrated membrane of Henle; under some conditions the perforations are absent and an elastic network exists in their place.

It is of importance to recognize this layer as it distinguishes clearly the boundary between the internal and middle coats in cases of pathological changes in either.

The middle coat is composed of elastic tissue and muscular fibres in varying proportions. "The thickness of the muscular tissue increases with the diminution of the calibre; the quantity of the elastic fibres, on the other hand, increases with the calibre" (Eberth).

The commencement of the aorta is said to possess no muscular fibre, while in the arterioles the elastic tissue is very scanty.

The arrangement of the elastic tissue is much the same as that which is found in the internal coat, being divided into fenestrated layers, which are connected with each other and with the internal elastic lamina by fibres of the same tissue. The muscular fibres are about $\frac{1}{250}$ of an inch in length, and are distributed in circular bundles about the artery and between the elastic layers.

The external coat is made up chiefly of white fibrous tissue, to which is added some longitudinal elastic fibres. Eberth and Bergens each describe the presence in this coat of longitudinal and, in some cases, of spiral bundles of muscular fibres.

Vessels, Nerves, and Lymphatics.—Arteries are supplied with vessels, nerves, and lymphatics. The vessels, which are termed "vasa vasorum," are derived from a branch of the same artery, or from some contiguous artery; they pierce the sheath, and after subdividing enter the externa coat to which they are distributed. They have neve been demonstrated in the middle or internal coats (Ran vier), and it is a question if the nutrition of the latter b maintained by the blood-current within the vessel, or b these nutrient arteries.

The nerves of an artery are derived from the sympa thetic system; they form plexuses about the vessel and sen off fibrils which terminate in the muscular fibres of th middle coat. An accessory nervous mechanism is found i the shape of small ganglia distributed irregularly through out the arterial system.

The most conspicuous property of an artery is elasticity which is given it by the yellow elastic tissue found in th internal and middle coats. The elasticity is most marke in the larger arteries, especially in the aorta at its com mencement. As the arteries grow smaller, the elasticity diminishes, and in its place appear contractility and expansibility, properties given it by the muscular fibres of the middle coat. These muscles are dominated by the

nerves, which are distributed to their nuclei, and which, known as vaso-motor nerves, contain dilator and contractor fibres; the elasticity, however, rarely disappears entirely, and is present as long as the yellow elastic tissue remains.

When an artery is cut across it retracts within its sheath, and the divided ends curve inward; it does not, however, collapse, as does a vein under like circumstances. These characteristics are again due to the presence of the elastic and muscular fibres of its coats.

VEINS are the afferent vessels of the heart; they commence at the capillaries as venous radicles, which by union with each other form the venous trunks. Veins are divided into two sets; one superficial, situated between the two layers of superficial fascia, and not accompanying arteries; the other, a deep set, following the direction of the arteries, and usually included in the same sheath with them. The large arteries are accompanied by but one vein; the smaller arteries, *i.e.*, the arteries of the forearm, hand, leg, and foot, are each accompanied by two veins (venæ comites).

Veins anastomose more freely than do the arteries, so that there is in all parts an ample provision for the return of the blood to the heart.

Peculiar veins are those of the vertebræ, the venous sinuses of the brain, and the portal vein, in that they do not accompany arteries and present certain peculiarities of structure.

Veins in general carry blue, or non-oxygenated blood; exceptions to this statement are the pulmonary veins, and the veins coming away from glands during their functional activity.

Veins possess walls, which are very thin as compared to their calibre, so that when cut across they collapse.

They are also quite distensible, and these properties render their apparent size a matter of uncertainty, for a vein which is easily distinguished when full of blood is difficult of recognition when empty and collapsed.

Although the veins have walls thinner than those of corresponding arteries they are stronger, and will sustain a greater weight without breaking.

Veins possess, in the majority of cases, three coats; the structure of these coats differs greatly in different portions of the venous system.

The part of the vein contiguous to the blood-current is made up of the common cell membrane. The endothelial cells of this membrane are shorter and less fusiform than those found in the arteries, but their general arrangement and appearance are the same. Directly outside of this membrane is an "intermediate layer," thin, and not distinct, which in turn is covered by an internal elastic lamina, not, however, as well developed as is the same layer of the arteries.

The middle coat is made up of muscular and elastic tissue in proportionately small amount, the elastic tissue not distinctly fenestrated; but mixed with them are considerable quantities of white fibrous tissue, the condition of structure from which the veins derive their greater strength.

The elastic and the muscular fibres are arranged for the most part circularly about the vessels. This arrangement of the muscular fibres is by no means constant, since some veins possess no muscular tissue.

According to their structure, Eberth divides the veins into two classes, non-muscular and muscular.

In the first division are included the veins of the pia and dura mater, veins of Breschet in bones, those of the retina, the external and internal jugular veins, and the veins of the maternal placenta.

Muscular veins are divided into four groups:

1. Veins with longitudinal fibres, as in the pregnant uterus.

2. Veins with an internal circular layer of fibres, and an external layer of longitudinal fibres, as in the vena cava inferior, the venæ azygoses; the portal, hepatic, internal spermatic, renal, and axillary veins.

3. Veins with an internal and external longitudinal, and a middle, circular layer of muscular fibres, as in the crural and popliteal veins.

4. Veins with circular muscular fibres, as in some of the veins of the upper and lower extremities.

In the thoracic portion of the inferior vena cava there is no middle coat.

The adventitia of the veins does not differ from that of the arteries, except that it is thicker, and in some instances possesses longitudinal elastic fibres.

The veins are furnished with valves, which are most numerous in the lower extremities.

The valves have usually two leaflets, and are situated directly below the orifice of a communicating vein. Each leaflet is semilunar in form, with the convex surface opposed to the blood-current.

At that portion of the vein where the valve is attached, the vessel is somewhat contracted, but just above the valves is a sinus or dilated pouch, an arrangement which allows the blood to pass in behind the valves, and thus to close them.

Each leaflet of the valve is composed of a finely fibrillated connective-tissue, covered with endothelial cells of the same variety as those lining the other portion of the vein; those upon the convex surface having their long axes parallel to the blood-current, while the axes of those upon the concave surface of the valve are transverse.

The superior and inferior venæ cavæ, the portal vein, the hepatic, renal, and uterine veins, the ovarian veins, the pulmonary veins, those of the cranium and vertebral canal, those of the cancellated tissue of bone, and the umbilical veins have no valves (Quain, vol. ii., p. 192).

Veins are nourished by blood-vessels in the same manner as the arteries, and are supplied, though not so freely, by the sympathetic system of nerves.

CAPILLARIES (capillus, a hair) are the smallest vessels of the circulatory apparatus. They connect the terminations of the arteries with the commencement of the veins, by a most freely anastomosing plexus, which from artery to vein is about one twenty-fifth of an inch in length.

The capillaries of a part, although freely communicating with each other, remain of uniform diameter throughout; those of the different tissues, however, vary much in size.

In diameter they average from $\frac{1}{3000}$ to $\frac{1}{2000}$ of an inch; but in nervous tissues and the retina they may be as small as $\frac{1}{6000}$ to $\frac{1}{4000}$ of an inch; while in glands and bone they may reach the size of $\frac{1}{1200}$ of an inch.

The plexus which they form is a very close one; the frequency of communication between the vessels varying with the tissue, and depending upon its nutritive activity.

The capillary networks in the lungs and the choroid coats of the eye are particularly rich, and in the first-named organ the spaces between the vessels are smaller than the vessels themselves.

The capacity of the capillary system is great, being from five hundred to eight hundred times greater than that of the arteries.

The structure of a capillary in its simplest form is that of the endothelial tube, which is continuous with the same membrane of the arteries and veins.

As seen under the microscope it is a delicate, double-contoured, dull membrane, in which oval nuclei are embedded at tolerably regular intervals.

If this membrane be stained with nitrate of silver, the boundaries of the cells composing it are distinctly brought to view, and are then seen to be of a more or less fusiform shape, with irregular serrated edges. Some of these cells are faintly granular.

Throughout the capillary system, small, dark spots are seen upon the inner surface, between the cells; these are evidently openings, known as stomata or stigmata.

At these points it was formerly believed that the white blood-corpuscles made their exit from the vessels, an assumption which has since been disproven.

As the capillary becomes larger there are added to it prolongations from the connective-tissue cells of the vicinity, which form a delicate tunica adventitia, a membrane, at first incomplete, but later becoming more fully formed, and known as the "external vascular membrane." With the further enlargement of the capillary, muscular fibres are added; at first these are few in number, but

they gradually increase in amount, so that when the capillary has become the arteriole upon one side, or the venous radicle upon the other, this muscular layer is quite distinct.

In all parts of the body the capillaries bear the closest relationship to the tissues in which they are found.

They are surrounded, in some instances, by structures that have the appearance of lymphatic sheaths, in other cases, especially in glandular organs, they pass directly through spaces which are the commencements of the lymphatic system.

The blood in the capillaries is separated from the tissues only by a single membrane, that is, the capillary wall.

The capillaries are elastic, contractile, and distensible, and both the fluid and solids of the blood make their way through their walls into the tissues.

The usual mode of communication between arteries and veins is by the capillary system; but in the spleen, in erectile organs, and in the placenta, blood is poured by the smaller arteries directly into spaces which resemble the veins in their structure. In these instances there is no capillary plexus, its place being taken by the blood-spaces or lacunæ.

The functions of the blood-vessels are, first of all, to act as channels for the conveyance of the blood as it circulates through the body. The larger arteries, by virtue of their elasticity, assist in propelling the blood toward the capillaries, and in so doing convert the stream from an intermittent into a continuous flow.

The smaller arteries, by virtue of their contractility, regulate, under nervous direction, the supply of blood to the different tissues.

In the capillaries, the active interchanges between the material of the blood and the tissues take place, processes permitted by the thinness of the capillary walls.

The veins return the blood to the heart, the readiness with which they collapse being a factor in the propulsion of the blood, as the muscles in action press upon their walls and force the blood out, the backward flow being prevented by the valves.

Diseases of the Arteries.—If we except aneurism, thrombosis, and traumatisms, the diseases of the blood-vessels are of more interest to the pathologist than to the diagnostician.

In most cases they are the further manifestation of the poisons of gout, syphilis, rheumatism, or nephritis, or are the result of changes consequent upon old age; and not only are their symptoms masked by the symptoms of the disease which they complicate, but so obscure and so inaccessible to ordinary diagnostic methods are their manifestations, that they are with difficulty recognized. Indeed, unless they produce some more than ordinary effect, for example cerebral apoplexy, their existence passes undiscovered, or is at best but surmised.

This is certainly the case in all the diseases of the arteries, with the exception, perhaps, of far advanced calcification, the presence of which can be recognized when the artery has become so changed that its elasticity is gone.

Classification of Arterial Diseases.—The diseases of the arteries are acute and chronic. The chronic are inflammatory and non-inflammatory. The inflammatory are two in number: first, inflammation with diminution in the calibre of the vessel—endarteritis obliterans, and, second, inflammation with increase in the calibre of the vessel—endarteritis deformans.

The non-inflammatory diseases comprise some of the degenerative processes to which other tissues are subject. The most common are the fatty, the amyloid, and the calcareous. Atheroma is a term applied to an association of chronic inflammation with one or more of the degenerations.

Tuberculosis of the arteries sometimes occurs, although but rarely.

Either of the coats of an artery may be involved, with the production of a peri-, meso-, or end-arteritis.

Acute arteritis is described as existing under two conditions: first, as a disease most often of the smaller arteries, complicating an adjacent inflammation, or a traumatism either within or without the lumen of the artery; or secondly, as a primary or isolated affection occurring in the larger arteries, and for the most part in the aorta.

In the first class of cases are included the changes occurring in an artery as the result of irritation from an embolus, those which are excited by deligation of an artery, and those which are set up in an artery by neighboring inflammations, such as a suppurating wound or an acute ulcer.

These various conditions have been described under other heads.

Opinion varies as to the existence of the second class of acute arterial disease.

It is doubtful if an acute isolated arteritis ever occur.

It was the custom of pathologists in the earlier part of this century (Frank, Puscheldt, Naumann) to look upon post-mortem imbibition, reddening of the tunica intima, and the deposition of fibrin upon the inner surface of a vessel, as evidence of its acute inflammation.

In 1847 Virchow, in an elaborate monograph, proved the incorrectness of these views. The truth of his statements was generally accepted, and the existence of an acute arteritis was denied by most pathologists.

But in 1868 Cornil and Ranvier, in describing the diseases of the arteries, asserted that they had seen several examples of this acute arteritis existing as an isolated affection.

In 1873 Moxon published a peculiar case of inflammation of the aorta, acute in character; and in 1878 Leger described eleven cases of acute arteritis, and gave the distinguishing symptoms of each.

These cases, published by observers of authority in the pathological world, revived again the possibility of the existence of such a disease as the one under discussion, and the term acute, applied to arterial disease, has again entered our nosology.

It is difficult, however, to recognize in the descriptions furnished by Cornil and Ranvier and by Leger the acuteness of the processes which they claim exists.

In all of the instances mentioned by Leger there was, besides the so-called acute process, a far advanced endarteritis deformans chronica, upon which the latter inflammation had been engrafted, and even the newly inflamed parts showed evidences of inflammation having existed far beyond the limits to which the term acute, as used to designate inflammation of other tissues, is applied.

It is by no means uncommon to find in an atheromatous aorta patches of inflammation which show evidence of having made more rapid progress than the surrounding diseased parts. These show, upon microscopic examination, a structure similar to that of the chronically inflamed parts, with the exception that it has not undergone the degenerative changes that the latter undergo.

These patches are reddened, softened, rarely ulcerated, and resemble in all respects the description of the "plaques gelatineuses" of Cornil and Ranvier.

Indeed, these patches show every evidence of being a primary stage of the chronic endarteritis which they complicate, and which, subacute in origin, ultimately undergoes the changes which the other portions of the aorta have undergone. Cornil and Ranvier and Leger have described, and most correctly, the primary subacute changes which take place in an artery undergoing deforming endarteritis; the application of their description is erroneous, for they have assumed that these changes were evidence of an acute disease, an assumption not warranted by the pathological appearances.

Moxon describes a case of inflammation of the aorta in which the ascending aorta and its orifice of origin were greatly contracted and diseased; there were two other patches of circumscribed disease, one at the commencement of the descending part of the aorta, and the other near the cœliac axis.

The inner surface of the diseased patch was like a circumscribed eruption. The surface was raised in folds and wrinkles, and had a bluish-white color and semipellucid appearance. The thickness of the parts was considerably increased.

The adventitia had the appearance of a fibrous belt, having in it small, yellow spots; these spots were composed of very small, inflammatory corpuscles, contained in a network of tissue. The disorder was acute, with spreading edges.

This case seems to present, more than any other, the appearances of an acute aortitis; but here again it is difficult to determine how long the affection had lasted, or what was its intensity.

Without discussing further the merits of this question, it would seem that the occurrence of an acute, isolated arteritis has not yet been proven, and that most of the cases presented as examples of this affection are but earlier manifestations of the chronic arterial inflammation.

Occasionally there is seen an acute affection of the aorta, which is known as endaortitis verrucosa acuta. Cases have been described by Weber, Heydloff, Gordon, and Marchand. This affection is distinguished by a growth of vascular granulations over a more or less extensive expanse of the aorta. In the case of Weber the entire inner coat of the aorta, in the ascending and transverse portions of the arch, was covered by these granulations.

In all of these cases the disease was coexistent with a similar inflammation of the semilunar valves, and was evidently but a further extension of the same.

Chronic Arteritis.—Though this question of acute arteritis may be involved in obscurity there can be no doubt about the prevalence or frequency of the chronic arterial affections.

In these chronic inflammations, the internal coat is primarily affected, and in it the most distinctive and compromising of the changes take place; the other coats take part in the disease, but not to an extent so marked, or at least so well recognized.

Endarteritis Obliterans.—Arterial inflammation, with diminution in the calibre of the vessels, was first described, by Heubner, in 1874, as one of the evidences of syphilis. The arteries in which he observed this process were those of the cerebrum, especially the basilar arteries. Since then it has been shown that this obliterating arteritis is not an uncommon disease, that it attacks other arteries besides those of the brain, and is found as a result of other diseases besides syphilis, although the latter is still held to be the most frequent and important cause.

The other situations in which such arterial disease is found are the liver, spleen, kidney, and lungs, especially when these organs are undergoing a connective-tissue change, as a result of gout, Bright's disease, rheumatism, or chronic alcoholism; it is also found in many new growths.

An artery thus inflamed has lost much of its elasticity, is hard to the touch, is whitish in color, and is not easily separated from its accompanying vein or veins.

After being dissected out it stands up like a stiff cord. This change is sometimes seen in arteries the size of the basilar, but is best marked in the smaller arteries, as seen in a section of the kidney affected by fibroid Bright's disease, or in a lung which has undergone the changes of fibroid phthisis, differing markedly in this from endarteritis deformans, a disease which attacks the larger arteries most frequently.

The microscopical examination of these arteries reveals that the distinctive changes have taken place in the tunica intima.

The internal elastic lamina, marking the boundary between the internal and middle coats, can be plainly distinguished. The middle and external coats are often not appreciably changed, but in the place of the delicate and narrow membrane, the normal intima, is a mass of newly formed tissue, encroaching upon the lumen of the vessel and reducing its calibre to a greater or less degree, and in some cases obliterating it completely.

The growth may start from one side of the vessel, compromising the lumen upon that side only; or the intima in its entire circumference may take part in the inflammatory process, so that the channel remaining for the passage of the blood may be situated laterally, or still be directly in the middle of the artery, although very much reduced in size. If the artery is completely obliterated the newly formed tissue is frequently canalized by new vessels, and in the older cases the tissue contains numbers of hæmatoidin crystals.

In regard to the intimate structure of this newly formed tissue, it is found to be made up of connective-tissue, with spindle cells and round cells embedded in a homogeneous interstitial substance, the cells nearest to the tunica media being flattened and the intercellular substance scanty, while those nearest to the lumen of the vessel are larger and more branching, with a considerable amount of intercellular substance. This change occurs within the substance of the internal coat, and, as it enlarges it, pushes ahead of it the normal endothelial lining, so that the inner surface of the vessels is still covered by the original endothelium.

The entire growth, in its earlier stages, resembles granulation tissue, distinguished by the presence of many embryonic and indifferent cells, which, with the progress of the disease, are converted into connective-tissue.

A peculiarity of this tissue is, that it does not tend to undergo any of the degenerations, although in the cases which have existed for a considerable period the nuclei of the connective-tissue disappear and the whole mass is converted into tissue that has no apparent structure, and is hyaline in the sense that it is translucent when cut into thin sections.

The outer and middle coats sometimes show evidences of a small-celled infiltration, which in some situations proceeds to the formation of fibrous nodules.

The appearance of a completely obliterated artery resembles greatly the obliterating process occurring in a ligatured artery, in which the broad ligature has been used and no rupture of the internal coat has taken place, in which, in other words, an acute traumatic endarteritis has been set up. In this instance, however, there is apt to be disappearance of the middle coat, an effect not observed in the idiopathic variety.

Endarteritis Deformans.—This is a disease which attacks chiefly the arteries of aged people, and especially the aorta and its larger branches. Fatty degeneration, atheroma, and calcification go hand in hand with it. An artery which has undergone the change is very much dilated, but irregularly so. It presents enlargements, and between them apparent constrictions, opposing no longer a smooth surface for the passage of the blood, and presenting a knotty, irregular interior. The walls are actually thicker, but are relatively thinner than normal, and their elasticity and contractility are much impaired.

The intima has lost its glistening appearance, and presents upon its surface the evidence of fatty degeneration in the form of white dots and streaks. Scattered through the vessel are patches of a white, horny-looking material, slightly raised over the level of the intima; these are the atheromatous foci; their surface is sometimes smooth, but often presents superficial loss of tissue, with the formation of an atheromatous ulcer. Oftentimes certain portions of the arterial coats are found to be hard and unresisting, as if changed to bone, and these are the plates of calcification.

There is no arterial change which presents so marked characteristics as this deforming inflammation of the internal coat, with its accompanying atheroma and calcification.

The enormous size which an artery so affected may reach, the marked alterations in its shape, and the hardness of its walls are changes easily recognized and not to be mistaken.

It is not difficult to describe the microscopic appearances of this affection, but it is not easy to determine the relations which they bear to each other.

The intima is very much thickened—three to four times. The changes are most marked in the strata nearest the media, and sometimes the outer layers of the latter are involved. The elastic line which marks the division between the two coats is usually obliterated.

The most noticeable elements in this thickened intima

are large spindle-shaped figures—Virchow's cells—which interlace with each other, and in doing so form a network of low-organized embryonic tissue.

The spaces between the cells vary in size, and are generally filled with fat in drops, so that there appear to be layers of fat one above the other, separated by layers of other tissue.

Some portions of the intima present all the appearances of having undergone a coagulation necrosis. Foci of small cells are seen in the immediate vicinity of the necrosed parts. Sometimes the intima undergoes a fibroid change, especially in its superficial parts. The process, however, does not end here, and portions of the intima undergo a further change, which constitutes the condition known as *atheroma*. This disease was so named by the older observers, from the resemblance it bore to the atheroma of the skin. The patches of white tissue seen upon the inner surface of the intima, and somewhat raised above its level, are the ones which have undergone further atheromatous change.

The view of Rokitansky, that they were layers of a membrane deposited upon the intima, is erroneous, for these patches are always covered by the endothelial layer of the intima, and are the result of changes in the substance of the intima.

In this portion of the diseased artery it is found that the spaces in the network, as seen in chronic endarteritis, are distended with fat; the cells themselves have undergone a fatty degeneration; the cellular substance has disappeared, and a larger space has been formed, containing plates of cholesterin and a granular detritus. This is known as an atheromatous focus. With the progress of the disease this gradually increases in size; it may unite with others, in time it softens, and then it is apt to break through the superficial layers of the intima, and, by doing so, to form an atheromatous ulcer, open to the blood-current, and discharging its contents into the circulation.

Within this softened tissue, or in its vicinity, it is customary for salts of lime to be deposited in glistening particles or large opaque masses (see Calcification of Arteries).

It is not difficult to recognize the microscopic changes in these kindred affections; it is less easy to determine the relations which each bears to the others.

The entire process is a combination of inflammation and degeneration.

The original disease is probably of an inflammatory nature, subchronic in character, and presenting few of the evidences of inflammation. Cornil and Ranvier attributed the inflammatory changes to the irritation exercised upon the surrounding tissues by the points of fatty degeneration, but it is probable that other causes have produced inflammation of the intima, and that, after this inflammation has caused the thickening of the intima, the newly formed and lowly organized new material undergoes the changes which are known as fatty degeneration, atheroma, or calcification.

It is most difficult of all to determine in which category to place atheroma. Virchow and the majority of later writers upon this subject, especially Moxon, have insisted upon a preceding inflammation of the intima as an essential part of the process, and apply the name atheroma to all the changes, inflammatory and degenerative, which have been described as occurring in endarteritis deformans. While it is probable that the atheromatous change most often follows an inflammatory stage, there can be no question but that atheroma in itself is a pure degeneration, and is not dependent upon a preceding inflammation for its appearance. It comes in this deforming inflammation of the internal coat, because this tissue, of all others, undergoes degenerative changes most easily; it does, however, appear in arteries which have not undergone this preceding inflammation.

A further substantiation of this view comes from the fact that atheroma, as calcification, comes in that portion of the artery subjected to the most strain, while a deforming endarteritis seems to have no dependence upon such a cause. In other words, the cause which produces endarteritis is different from that which produces atheroma, the former, however, in the majority of cases, being unable to produce atheroma except in previously inflamed tissue.

Again, calcification of the arteries, so often associated with atheroma, does not always follow upon inflammatory changes in the intima, although it more frequently is a further change of, or an affection occurring with, chronic endarteritis, and as this last accompanying degeneration is not dependent upon an inflammation, although it is so often its sequela, it is probable that atheroma is of the same nature in this regard, and may or may not appear with inflammatory changes.

Calcification of the Arteries.—The question of calcification of the vessels is that of calcification of other tissues, and the exciting and preceding changes are here the same as elsewhere. These are best studied in the smaller arteries, for here the change is usually a primary one, and is not complicated by either the inflammatory or the other degenerative processes.

In primary calcification the disease begins in the middle coat, and rarely involves the outer or inner coat, except by encroachment. The muscular tissue of the media is replaced by salts of lime in greater or less amounts, forming plates, which are sometimes translucent, but oftener opaque, especially if the process is far advanced.

The tissue in the vicinity of these plates shows the evidences of a mild form of inflammation, resulting from the irritation which, as foreign bodies, they exert; these evidences of inflammation are in the form of foci of undifferentiated cells, which are sometimes converted into a fibroid material.

If these calcareous plates be treated with a dilute acid, so that the lime salts are dissolved out, there remains the tissue which has served them as a nidus.

This tissue is the muscular coat, which has undergone a peculiar change, described by Weigert as "coagulation necrosis;" within the limits of the diseased tissue the muscular cells have lost their nuclei and the tissue has a peculiar stiff appearance. This result, according to Weigert, is produced by nutritive changes, which cause the death of portions of the arterial coat; the cells, in dying, give up the ferment which, according to Schmidt, is necessary to the process of coagulation, and the setting free of this ferment causes coagulation of the lymph which bathes the tissues, converting the necrotic portion into a stiff, coagulated, non-nucleated condition, known as coagulation necrosis.

The tendency of such tissue is to collect within its limits salts of lime, and while it is possible that calcification of a tissue may occur without the preceding change, certainly in the majority of cases coagulation necrosis is the precursor.

Litten has succeeded in demonstrating this experimentally, in the production, upon animals, of artificial infarction of the kidney.

The salts, which as in other calcified tissue are those of lime and magnesium, are deposited first in the intercellular structure; the arrangement of the salts is irregular, and in no instance does the calcified tissue take on the structure of bone.

The calcification of the large arteries is a secondary process which has for its seat the thickened intima which comes as a result of an endarteritis deformans. It goes hand in hand with atheroma and fatty degeneration of the vessels, and differs in this marked essential from primary calcification, that while the latter attacks an otherwise normal media the *secondary change* is found in the embryonic, badly nourished, and easily degenerating new products of a chronic endarteritis.

In this variety of calcification the masses of lime salts are found in the deepest layers of the thickened intima, sometimes reaching to the surface and exposed to the blood-current, and sometimes encroaching upon the media; the immediate vicinity is surrounded by newly formed inflammatory corpuscles, and the remaining portions of the intima show the star-formed figures of chronic endarteritis, with generally more or less fatty degeneration, and in many cases atheromatous centres, or even ulcers.

Treatment of these calcareous plates with an acid does not give the positive results obtainable in the smaller arteries.

The tissue remaining after dissolving out the lime salts does not present the same appearance in all portions. This is probably because the enlarged intima shows different degrees of inflammation. Portions of the tissue remaining show, however, unmistakable signs of having undergone a coagulation necrosis, and it is probable that all of the tissue which was impregnated with lime salts had undergone this change. This statement is not easy of proof, as the changes in these calcareous spots are masked by the inflammation and degenerations in their immediate vicinity.

The macroscopic appearances of a calcified artery are unique. It is less elastic, less retractable, and, when cut across, stands with open lumen. If the plates of chalk are large they are easily distinguished by the touch, and, when cut through, by the increased resistance presented to the instrument.

These plates may be isolated and few in number, those at least that can be recognized by the naked eye, or they may be so large and so numerous as to convert the artery into a rigid, non-elastic, stone-like canal. When they are present, even in small amount, the shape of the artery is changed, the inner surface is rough and uneven, and the blood-current is thereby changed in velocity and direction.

In the large arteries, as the aorta, the intima presents the swollen yellow spots distinctive of atheroma; these are not so often met with in the smaller arteries.

Fatty degeneration of the arteries is a constant accompaniment of endarteritis deformans and atheroma. Cornil and Ranvier describe a primary fatty degeneration of the vessels existing without the complication of an arterial inflammation, and which, they hold, plays an important rôle in the production of arteritis.

By far the most frequent appearance of fatty degeneration is as a secondary affection. An artery thus diseased presents upon its surface white or yellowish-white patches, sometimes of a uniform color, sometimes striated. When examined by the microscope, these are found to be made up of drops of fat and fatty granules, situated in the internal coat, and often between the fibres of the middle coat.

Amyloid degeneration of the arteries is frequently met with. Rarely are arteries larger than the arterioles attacked. Those of the spleen, kidney, liver, intestines, and brain suffer the most. The middle coat is most frequently infiltrated with the amyloid material (see Amyloid Degeneration).

Causes of Arterial Disease.—The causes of endarteritis obliterans are, as above stated, those which give rise to general connective-tissue formation, syphilis, gout, rheumatism, and alcoholism.

Endarteritis deformans, atheroma, and fatty degeneration most often occur in aged people, rarely are they seen under fifty, and more frequently over sixty years of age.

To gout, rheumatism, and syphilis have been attributed special rôles in the production of these kindred affections; but it has been shown, first by Rokitansky, and of late years insisted upon by Moxon, that *strain* is the most important factor in their causation. For not only are these diseases most frequently met with in athletes and working-men, but they occur at the parts of the arteries subjected to the most dilatation from the impingement of the blood-current.

Such points are the arch of the aorta, the mouths of the coronary arteries, the points of division of the abdominal aorta into the common iliacs, and again the points of division of these latter arteries, the posterior tibials as they wind behind the internal malleolus, and, finally, the arteries of the brain. At all of these points the arterial walls are almost continually undergoing the greatest amount of expansion, and these points are the first to undergo the degenerative changes.

The cause of calcification of the arteries is to be sought for among the causes which produce coagulation necrosis. That these are nutritive changes directly dependent upon the supply of arterial blood is not to be questioned, but what the ultimate exact change in the blood-supply may be has not yet been determined. It has been proposed that emboli of the vasa vasorum might be guilty of cutting off the nutrition of the arterial walls, as in the analogous process of kidney infarction, but such emboli have not been demonstrated.

It is not difficult for us to understand that this coagulation necrosis would occur more readily in a chronically inflamed tunica intima, knowing as we do the readiness of this new tissue to undergo degeneration.

Effects of Arterial Disease.—The effects of chronic arterial disease are very important. On the one hand is a disease which obliterates the lumens of the vessels, which destroys in large part the capacity of the circulatory system, and in doing so shuts off the nutrition from important organs and tissues; on the other hand is a disease which, while it does not actually obstruct the blood-current, so changes the arteries that their elasticity and contractility are impaired, and the most potent causes in the regulation of the proper blood-supply of the tissues are gone.

But although these changes are so compromising, arterial diseases produce very few distinguishing symptoms. The existence of endarteritis obliterans can only be surmised, not proven, and only surmised when, in the course of syphilis, gout, or rheumatism, an organ, especially the brain, shows a gradual and slowly developing failure of proper nutrition. When aneurism occurs, the pre-existence of endarteritis and atheroma may be inferred, but under other circumstances their detection is as difficult as is that of the obliterating endarteritis, unless the arteries have undergone the further change of calcification.

When the superficial arteries—temporal, radial—are markedly calcified, their condition may be appreciated by the touch. The artery can be felt under the skin as a hard, pulsating cord. It has lost its elasticity and compressibility. But if the aorta be calcified there is no means of determining it, for the amount of calcification in the smaller arteries is no criterion of that which has occurred in the aorta and larger arteries, or *vice versa*.

Calcification of the arteries must be looked upon as a conservative process, as an attempt on the part of nature to fortify and strengthen those portions of the arterial walls which have been weakened and which would otherwise be liable to rupture; but advanced calcification is in itself a very serious lesion; for aside from the marked changes in the circulation which it entails, the deformed shape of the arteries and the roughening of the inner coat from the projection of calcareous plates are fruitful in the production of thrombi and the train of symptoms following the occlusion of an artery.

Calcification of the arteries of the lower extremities is the chief cause of senile gangrene, and calcification of the coronary arteries is found to exist in most cases of angina pectoris.

In the application of a ligature to a calcified artery much care must be taken, as, in its diseased condition, the changes which ordinarily follow the application of a ligature do not take place perfectly, and sloughing and secondary hæmorrhage may follow.

Diseases of Veins.—The diseases to which veins are prone, while resembling in character those of the arteries, differ widely from them in degree and in the results they produce. These differences are due to the non-similarity in structure of the veins and arteries, the collapsibility of the veins, the frequency and completeness of their anastomoses, and the slowness of their blood-current. As they are in nowise subjected to the strain the arteries are constantly undergoing, one of the most fruitful causes of endarteritis deformans, and its further expression, aneurism, is removed. But, on the other hand, the superficial situation of many of the veins exposes them more frequently to traumatic influences, and the inflammation which is the result of these influences.

The most important factor in all of the diseases of the veins is the readiness with which they cause thrombosis.

This is due to the fact that when the veins are not filled with blood, their walls are nearly if not quite in contact with each other, and as the blood-current is slow and not

powerful, fibrin deposited upon their walls is not swept away, as in the case of the arteries, and a clot readily extends from wall to wall.

Either of the coats of a vein may be inflamed, with a resulting endo-, meso-, or peri-phlebitis. As a matter of fact, when one coat is primarily involved the remaining coats share in the inflammation. The limitation of diseases to one coat is not so closely drawn as in the arteries.

Diseases of the veins are acute and chronic. Acute phlebitis may be either adhesive or suppurative. Under certain circumstances a vein which is bathed in pus, as in the instance of a vein on the wall of an abscess, may become tumefied, inflamed, and suppuration may take place in the external coat.

In cases of pyæmia the veins are filled with pus and the intima participates in an acute suppurative process. (For a consideration of these processes see Abscess, Pyæmia.)

Acute adhesive inflammation of the vein is caused either by traumatism, as from bleeding or ligature of the vein, by changes in the character of the blood circulating in the veins, or by the presence of some poison in the blood.

Obliteration of the vein and the formation of a thrombus is the result of this non-suppurating form of phlebitis (see Thrombosis).

The chronic diseases of the veins are several in number.

In some cases veins are met with which have undergone changes resembling those seen in endarteritis deformans.

Such veins are elongated and of varying calibre. They present constrictions and dilatations, the dilatations amounting in some cases to well-marked pouches filled and distended with blood. In the severer forms of the disease the vessels are curved upon themselves, and if superficial, they can be rolled under the finger like a cord.

The valves are insufficient, either from retraction of one of their leaflets or from its adherence to the side of the vein. When the vein is cut open its walls show differences in thickness, at one point being strong enough, perhaps, to gape open like an artery, at another collapsing as a vein usually does. At times portions of the veins show calcified plates and ulcerous spots resembling in each case those so frequently found in chronic arterial disease.

Seen under the microscope the changes are found to resemble those of endarteritis deformans chronica. The most marked of these changes take place in the intima and the inner part of the media. These coats are thickened and present points of fatty degeneration, points of coagulation necrosis holding lime salts within them and other portions of tissue, showing an atheromatous débris.

This condition of the veins, as stated above, is rare, because the causes which lead to the formation of the arterial disease of which it is an analogue, are wanting in the majority of cases. It is sometimes seen in veins which are habitually over-distended, as in the portal vein, in cirrhosis of the liver, and in varicose distention of the veins, especially of those of the lower extremity.

While this chronic endophlebitis is not to be looked upon as being in all cases the primary lesion in varicosities of the veins, its presence under such circumstances occurs more frequently than is generally suspected. This fact has been especially insisted upon by Negretti.

Tuberculosis of the veins occasionally occurs. Cases have been described by Weigert and Schuchardt.

According to Weigert, the tuberculous masses are seen in veins which have become united to tuberculous lymphatic glands, or to other tuberculous masses, especially those found in the liver, lungs, or spleen.

These masses encroach upon the walls of the veins, and at times lie free exposed to the blood-current.

Such masses are about the size of the head of a pin, and present either a smooth or an ulcerated surface, covered with masses of fibrin. Microscopically the masses have a cheesy centre, and the usual small-celled periphery of an ordinary tuberculous mass. The fact of such a condition existing is interesting, in that it may explain the mode of tuberculous infection of other tissues from a single tuberculous centre.

William L. Wardwell.

BLOUNT SPRINGS, ALA. *Location and Post-office*, Blount Springs, Blount County, Ala.

ACCESS.—By Louisville & Nashville Railroad, Louisville & New Orleans Division, to Blount Springs Station.

ANALYSIS (Professor R. Brumby).—One pint contains:

	Red sulphur.	Sweet sulphur.
	Grains.	Grains.
Carbonate of magnesia	0.55	0.45
Carbonate of iron	0.24	0.14
Carbonate of lime	0.85	0.56
Chloride of sodium	4.04	3.86
Chloride of magnesium	0.75	....
Sulphate of magnesia	0.20	0.30
Total	6.63	5.31
Gases.	Cub. in.	Cub. in.
Carbonic acid	0.75	0.75
Sulphuretted hydrogen	1.87	1.57

THERAPEUTIC PROPERTIES.—This is a saline sulphur water, and the locality has long been a favorite resort. The elevation is 1,580 feet. The surrounding country is mountainous, affording a healthful change to the inhabitants of the prairies and lowlands farther south.

G. B. F.

BLUE LICK SPRINGS, KY. *Location and Post-office*, Blue Lick Springs, Nicholas County, Ky.

ACCESS.—By the Kentucky Central Division of the Chesapeake & Ohio Railroad to Carlisle Station, thence by stage. There are two "Blue Lick Springs," "Upper" and "Lower," a few miles apart. The waters are very similar in their chemical composition.

ANALYSIS.—One pint contains:

	J. F. Judge and A. Fennal. Upper Blue Lick.	Robert Peter, M.D. Lower Blue Lick.
	Grains.	Grains.
Carbonate of magnesia	0.018	0.017
Carbonate of lime	3.133	1.957
Chloride of potassium	0.225	0.174
Chloride of sodium	64.[illegible]67	64.107
Chloride of magnesium	4.716	4.049
Sulphate of potassa	1.622	1.117
Sulphate of lime	5.517	4.249
Iodide of magnesium	0.019	0.006
Bromide of magnesium	0.476	0.036
Alumina-phosphate of lime and oxide of iron	0.246	0.045
Silicic acid	0.125	0.138
Loss	1.860	2.216
Total	72.524	79.105
Gases.	Cub. in.	Cub. in.
Carbonic acid	6.02	12.35
Sulphuretted hydrogen	1.02	2.28

THERAPEUTIC PROPERTIES.—These are representative saline-sulphur waters, and the most popular in the Southwest. They are cathartic and alterative. In chronic catarrhal diseases of the mucous membranes (alimentary canal, bladder, pharynx, etc.) the Blue Lick Springs are very efficacious. They are located on the banks of the Licking River, and were known and used by the Indians and pioneers. The flow is enormous, and the proportion of sodium chloride so great that the early settlers evaporated the water and obtained an ample supply of salt. The neighboring country abounds in springs, the composition of which is analogous to those which have been developed.

George B. Fowler.

BLUE RIDGE SPRINGS, VA. *Location and Post-office*, Blue Ridge Springs, Botetourt County, Va., immediately on the line of the Norfolk & Western R. R., forty-one miles west of Lynchburg. Open for visitors from June 1st to October 15th. The geology of the locality is quite like that of the neighboring Alleghany Springs, being magnesian-limestone principally, and, as might be inferred, the waters are very similar in their composition.

ANALYSIS (F. A. Genth).—One pint contains :

	Grains.
Magnesium carbonate	0.223
Ferrous carbonate	0.037
Calcium carbonate	0.472
Sodium chloride	0.031
Potassium sulphate	0.050
Sodium sulphate	0.122
Magnesium sulphate	5.944
Calcium sulphate	12.527
Alumina	0.018
Silicic acid	0.157
Total	19.581

THERAPEUTIC PROPERTIES.—This is a purgative lime-water. Taken in moderate doses, however, it is either gently aperient or without cathartic effect; but under these conditions full diuresis is generally established, the lime counteracting the effect of the magnesium sulphate (Epsom salts) upon the bowels, and diverting it to the kidneys. The efficacy of these Springs was familiar to the Indians, but, until a few years ago, the general public knew little about them. Their steadily increasing popularity is an evidence of their real value in dyspepsia, constipation, chronic cystitis, etc.

The *accommodations for guests* consist of a commodious hotel, and cottages connected therewith by a covered bridge. The grounds are extensive and handsomely laid out, and every provision is made for the entertainment of the guests. Situated 1,300 feet above the sea, the air is dry and exhilarating, the nights always cool, and the thermometer rarely rises above 87° F. in the day. There are many points of interest in the vicinity easy of access, and the mountain scenery round about is especially attractive. Botetourt Female College, seven miles; Roanoke College, fourteen miles; Bellevue College, twenty-five miles distant. *Geo. B. Fowler.*

BLUE SULPHUR SPRINGS, W. VA. *Location and Post-office*, Blue Sulphur Springs, Greenbrier County, W. Va.

ACCESS.—By the Chesapeake & Ohio Railway, to Alderson Station, thence by stage to the Springs, nine miles.

ANALYSIS.

	Grains in 100 cub. in.
Sulphate of lime	20.152
Sulphate of magnesia	2.760
Sulphate of soda	7.020
Carbonate of lime	2.185
Carbonate of magnesia	0.407
Chloride of sodium	1.868
Chloride of calcium	0.005
Protoxide of iron	0.015
Azotized organic matter (blended with sulphur)	3.000
Total	37.412

Gases.	Grains in 100 cub. in.
Sulphuretted hydrogen	0.56
Nitrogen	3.25
Oxygen	0.56
Carbonic acid	2.75

Temperature, 45° F.

These are calcic sulphur waters.

THERAPEUTIC PROPERTIES.—These waters are applicable to chronic skin affections and gastric catarrh; on account of the large proportion of lime-sulphate present they are not purgative.

These Springs are situated in a valley among the pine-clad mountains of West Virginia, about twenty miles from the celebrated White Sulphur Springs. The climate is invigorating, the temperature in summer ranging from 60° to 75° F. The scenery of this region is very picturesque, with delightful walks and drives, affording charming views of the surrounding mountain peaks.

HOTELS.—At present there are no accommodations for guests. Previous to the burning of the hotel, these Springs were quite a favorite resort, and with a renewal of accommodations they will no doubt regain their popularity. *G. B. F.*

BOILS. Synonyms: Furuncle (*furere*, to rage), phyma (φῦμα, a tumor), furunculus; Ger., *Furunkel*, *Blutschwär;* Fr., *Furoncle.* A boil, or furuncle, is a circumscribed inflammation of the skin, of the subcutaneous connective-tissue, or of both, leading to the formation of a dusky red, painful tumor, which usually suppurates slowly and terminates only after the discharge of a central core. Furunculosis is a term applied to a condition in which a number of boils appear in succession upon an individual.

A classification of boils is not easy. The old division of boils into furunculus simplex, vespagus, pannulatus, according to whether the pus appears through one or several openings, or through a cleft opening, is antiquated and useless. Neumann's classification of: 1, follicular, and 2, connective-tissue boils, is probably not a correct one. That of Kochmann, of sweat-gland and sebaceous-gland boils is based upon pathological differences which do not always admit of distinction. A classification based upon the *symptoms* of boils is the most useful. Under such a head it is possible to distinguish at least two varieties: 1, the acute; 2, the chronic or indolent. Boils may also come singly or in numbers. While it is not possible to entirely reconcile these different classifications, it may be said that the single boil is usually a complete, an acute, a follicular, or a sweat-gland boil; while in furunculosis many of the boils are of the indolent, chronic, incomplete, blood, connective-tissue, or deeply seated sweat-gland variety.

PATHOLOGICAL ANATOMY.—As boils rarely cause death, but little opportunity is afforded for determining their exact mode of formation. Examination of the core shows it to be made up of "pus-corpuscles and necrotic tissues, which microscopically and chemically show the greatest correspondence with coagulated albumen." This is evidently the product of a simple inflammation leading to suppuration, and it is not difficult to suppose that the various nervous and circulatory changes are the same here as in simple inflammations of other tissues. It is more difficult to determine in which one of the integumentary structures this inflammation originates. As boils appear most frequently in those situations in which sweat-glands are numerous, it is probable that the starting-point of the furuncular inflammation is in or around the glandular structures of the integument, spreading thence to the subcutaneous connective-tissue in some instances, and involving all the layers of the skin. Whether the inflammation can originate in the subcutaneous connective-tissues, as Neumann claims for his "connective-tissue" boil, is not determined; but it is more probable to assume that such a boil, which is deeply seated and indolent in character, is also glandular in origin, and begins around the glands which pass from the integument into the subcutaneous tissues.

It is probable, as claimed by Kochmann, that the first step in the formation of a boil is the occlusion of one of these glands; it is evident, however, that in many cases an irritant of some kind, usually an external one, plays an important rôle in exciting the inflammation which follows the occlusion of the gland.

When no such irritant can be determined, it has been customary to assume that some morbid blood condition supplies the necessary inflammatory impetus. If, however, as Neumann asserts, the arteries and veins leading to the base of the gland are always thrombosed, it can easily be seen that conditions exist in the gland which are quite sufficient of themselves to set up an inflammation of an intensity capable of producing a furuncle.

CAUSATION.—The causes of boils are constitutional and local. Many individuals seem to be predisposed to the formation of boils; this is especially the case when the vitality of the system is lowered, although they sometimes appear in persons apparently otherwise in perfect health. Boils are very frequent after a course of sea-bathing; after a change of diet, especially during a course of training for athletic contests; during convalescence from various fevers, such as typhus and typhoid; during the course of scurvy, of diabetes, and of chronic Bright's disease.

Children during dentition are predisposed to the formation of boils, as are also scrofulous and rickety children.

In the latter they at times appear in such numbers that the child is said to possess a "furuncular diathesis." Boils sometimes appear during the progress of pyæmia, a product of the same cause which forms abscesses in other portions of the body. The local causes of boils are uncleanliness, excessive perspiration, the occlusion of sebaceous follicles or of sweat-glands, the excessive use of poultices, the application of irritants to the skin, and especially the constant chafing of constricting parts of the clothing.

SITUATION.—The most frequent situations for boils are the back of the neck, the axilla, the perineum, the nates, and the thighs.

SYMPTOMS.—A boil begins as a small, hard, and painful nodule, which, situated in or underneath the skin, is easily appreciated by the finger. Its prominence depends upon the depth at which it is situated. It gradually enlarges; the integument over it becomes red and the tissues about it become indurated. It is excessively tender to the touch, and the pain is continuous, and of a throbbing character. As the boil progresses the integument covering it changes to a dusky blue, its apex becomes œdematous. About the fifth day a small white point of suppuration appears; from this time suppuration goes on rapidly, and as a result a central core is discharged upon the seventh to the ninth day, leaving an irregular opening. With the discharge of the core the symptoms subside, and the loss of tissue consequent upon suppuration is repaired by granulation and cicatrization. While this is the classical course of an acute boil, that of an indolent boil is different. Being more deeply situated, the tumor it forms is not so prominent. It suppurates more slowly, and the pus takes longer in reaching the surface of the skin; as the exit for the pus in this direction is not easy, the subcutaneous connective-tissue becomes involved, and the inflammation is more diffused, the pain is more intense, and the whole disease is more prolonged.

Some boils do not suppurate, and to them is applied the term "blind;" they are sometimes almost interminable in their chronicity, but are rarely painful, except upon pressure.

The constitutional effects of a boil are usually not marked. At times, however, they are very severe, especially if the boil be very large, if several appear in succession, or if the situation be such as to cause great pain, or to interfere with some one of the functions of the body.

Chills, fever, and all the concomitants of an inflammatory disease are sometimes marked. The lymphatic glands in the neighborhood become swollen and painful; while, if the boil be situated in tissue so tense that the escape of the inflammatory products is difficult, the pain becomes excruciating, and from its very intensity causes great constitutional disturbances; such situations are the external meatus of the ear and the perineum.

Then, too, further constitutional effects may be provoked if the boil be in such a situation as to interfere with one of the functions of the body; this is especially the case if a perineal boil be so large as to interfere with urination or defecation. A boil situated upon the thigh may prevent normal locomotion, while with those upon the buttocks, the patient is either obliged to stand or to assume the prone position.

Furunculosis occurring in the weak and cachectic is always exhausting, and sometimes dangerous, several cases being on record in which a long-continued succession of boils has caused death.

TREATMENT.—In the treatment of boils attention must first be paid to the general condition of the patient, and the tendency to their formation must be corrected. This may be effected by attention to hygienic principles and the use of tonics; besides this, several remedies have been extolled as specifics in conditions of furunculosis. In especial repute are the sulphide of calcium given in doses of one-tenth to one-fourth grain, the syrup of the hypophosphites, and, in a lesser degree, arsenic, iodine, and yeast. Planat recommends highly the use of arnica internally, and applied directly to the boils, claiming that its efficacy is due to constriction of the vessels through irritation of the vaso-motor nerves.

The local treatment of boils consists in attempting to abort them, if seen in the earlier stages. This can sometimes be accomplished by deep incisions, which relieve the tension of the inflamed tissue and always afford relief, even if they are not successful in preventing the further progress of the disease.

A most successful method is that recommended by Eade, of introducing a drop of carbolic acid into the apex of the boil, and working it thoroughly into the inflamed tissues. His claim, however, that furunculosis is a parasitic disease, and that this treatment owes its success to the destruction of these parasites, has no foundation on facts.

Other remedies for this purpose are blistering collodion, the tincture of iodine, and ice. If suppuration has commenced, it should be hastened, and the pain relieved by the use of warm applications or of poultices; rather than wait for the boil to "break" it is better to incise it, to evacuate the pus and core, and, by bringing the sides of the opening forcibly together, to hasten the cicatrization.

William L. Wardwell.

BOLDO (*Codex Med.*), *Peumus Boldus* Molina; Order, *Monimiaceæ*. This is a small, rough-hairy, aromatic evergreen tree, from Chili, having opposite nearly sessile leaves, and mixed panicles of regular, diœcious flowers. These consist of a cup-shaped receptacle or calyx-tube bearing from six to twelve white, unequal, more or less petaloid, divisions on the border and numerous stamens with glandular bases upon the inner surface. In the fertile flower the perianth is smaller, the stamens are reduced to sterile filaments, and a few carpels arise from the base of its shallow tube. After blossoming, the upper half of the perianth separates by a transverse fissure, and falls away, leaving a saucer-like disk around the single-seeded edible fruits. The leaves are the portion employed; they are coriaceous, entire, ovate, or elliptical-ovate, blunt, rough, and reddish upon the surface, which is sprinkled with numerous forked, bent, or stellate hairs. They have a pronounced mint-like odor and contain numerous large, simple oil-vesicles in the interior.

The constituents are a yellow, spicy *Essential Oil*, with the medical properties of other aromatic oils and an alkaloid, *Boldine*, of whose value not much is yet known.

Boldo has been considerably used in France as an aromatic tonic in convalescence from fevers, in chlorosis, anæmia, etc. It is also employed in South America for similar purposes, as well as in "hepatic troubles, gonorrhœa," etc. It is probably simply an aromatic tonic, like magnolia and others. The oil may be worth a trial in chronic cystitis and gonorrhœa. The drug is rather new in the United States; its final value and place can hardly be regarded as established. Dose: of the leaves, from one-half to one gramme (gr. viij. ad xvj.). Alcohol extracts their virtues.

The *Oil* may be given in doses of from one to three decigrammes (0.1 to 0.3 = gtt. ij. ad vj.).

ALLIED PLANTS.—The order, although a rather large one, is wholly tropical and unfamiliar. Its species are generally aromatic, but no other medicine in European use is obtained from them, unless the nutmeg (*Myristica*) is to be included among them.

ALLIED DRUGS.—The aromatic tonics (see MAGNOLIA), besides artificial combinations of aromatics and bitters, *e.g.*, Compound Tincture of Cinchona. *Boldine* is not sufficiently well known for closer comparison. The *Oil* may, perhaps, be compared with Oil of Sandal-wood.

W. P. Bolles.

BONE (HISTOLOGY). Bone-tissue is closely allied in genesis and in many of its structural features to the other members of the connective-tissue group, the most evident difference between it and other tissues of the same class consisting in the solidity and firmness of the basement substance. For in this, as in other connective-tissues, we have to consider the cells and the basement substance and the way in which they are arranged to form the different varieties of tissue. The solidity of the base-

ment substance of bone depends largely upon the deposition within it of calcium phosphate and carbonate, with small amounts of calcium fluoride, sodium chloride, and salts of magnesium. These inorganic salts, which form about two-thirds of the weight of the bone, are deposited in an organic matrix in such a condition of minuteness that they are not recognizable as particles even with high powers of the microscope. They may be dissolved out of the bone with dilute acids, leaving a translucent flexible material behind, which preserves the shape and general structural features of the bone.

The soft matrix which is left, after the extraction of its inorganic salts, may be converted into gelatin by boiling in water. It is sometimes called the cartilage of bone, or ossein, but there is no sufficient reason for using these names, since the matrix is really, both in chemical nature and minute structure, closely allied to the basement substance of fibrillar connective-tissue.

The varied gross appearances which different bones or different parts of the same bone present have given rise to the names *compact bone-tissue* and *cancellous bone-tissue* or *spongy bone*. But the essential structure of the tissue is the same in both, the difference consisting largely in the arrangement of the bone-tissue proper, and its abundance in proportion to the marrow-spaces or vascular canals which it encloses. The compact bone-tissue is in general found in the outer portions of the bones, while the cancellous tissue is situated internally, either entirely filling the central portions or bordering the marrow-cavities.

Bones are surrounded by a layer of vascular connective-tissue called the *periosteum*, and contain, either in large

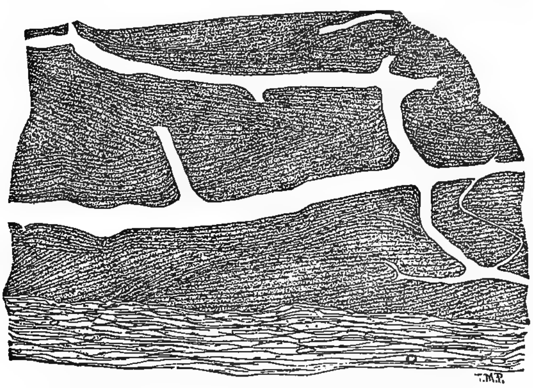


FIG. 485.—Longitudinal Section of Human Tibia, Decalcified and Mounted in Glycerine. (× about 20 and reduced.)

central cavities or in the smaller spaces with which they are everywhere permeated, a delicate vascular tissue called *marrow*. We have, then, to consider: 1, bone-tissue proper; 2, the periosteum; 3, the marrow.

1. Bone-tissue proper. If we remove the inorganic salts from one of the long bones, by soaking it in dilute chromic or picric acid (see article on Microscopical Technology), and then make a thin longitudinal section, microscopical examination with a low power of these sections, stained with eosine and mounted in glycerine, reveals a picture like that represented in Fig. 485. The more solid portions of the bone show a series of narrow canals, running in a direction in general parallel with the long axis of the bone, and in frequent communication with one another by similar short transverse or oblique canals. These are the so-called *Haversian canals*, and contain blood-vessels, and, depending upon their size, few or many variously shaped cells. Along these Haversian canals the basement substance will be seen arranged in a series of lamellæ, while in and between these lamellæ lie small, elongated cavities called lacunæ, in which are the bone-cells. Transverse sections, however, through the middle of a long bone, reveal with more distinctness the arrangement of the lamellæ of the basement substance (Fig. 486). The Haversian canals, which are cut transversely or obliquely across, are surrounded by a series of concentric lamellæ. These Haversian lamellæ, with their enclosed lacunæ, together with the canals and their contents, form the so-called *Haversian systems*, *d*. Filling the larger and smaller irregular areas between the Haversian systems are other parallel lamellæ, which run in various directions, and which are called *intermediary systems*. Beneath the periosteum, at the external surface of the bone, is a thinner or thicker system of lamellæ called *circumferential* or *general lamellæ*, *b*, which cover over large numbers of the Haversian systems and surround the entire bone. Sometimes similar but less well-defined general systems of lamellæ border the marrow cavity, but more often the internal surface of the compact bone is beset with a series of projecting bony trabeculæ, *e*, consisting of lamellæ similar to those forming the systems of the compact bone, and inclosing large, irregular spaces. This is the cancellous tissue bordering the marrow cavity. In the heads of long bones, and in most short or irregular-shaped bones the cancellous tissue occupies the entire central portion.

If, now, we study more closely the minute structural features of the bone, we find in the first place that the Haversian canals, as seen in transverse sections of the bone, vary considerably in size and shape. Some are large, others small; some are round, others oval, others irregular in shape. In many cases, however, the oval

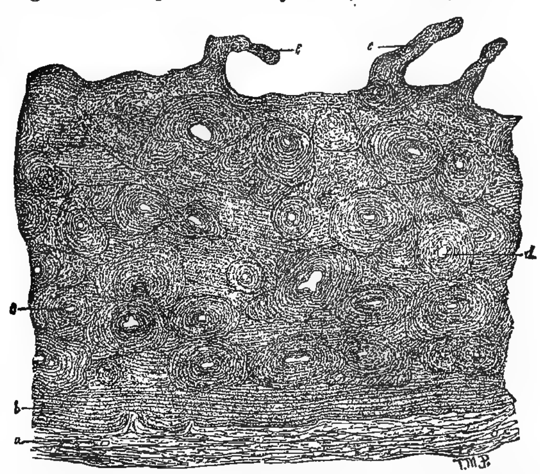


FIG. 486.—Transverse Section of Human Tibia, Decalcified and Mounted in Glycerine. (× about 15 and reduced.) *a*, Periosteum; *b*, circumferential lamellæ; *c*, Haversian system of lamellæ; *d*, Haversian canal; *e*, trabeculæ of cancellous tissue bordering the marrow-cavity.

shape of the Haversian canals and of their systems of lamellæ appears to be due to the obliquity of the section. In some cases the canals lie in the centre of the systems, in others near the side. Sometimes the Haversian systems are complex, one set of concentric lamellæ seeming to have encroached upon the space formerly occupied by another, Fig. 486, *c*. Furthermore, the borders of many of the Haversian systems, where these abut on one another, or upon the intermediary systems, appear scolloped or jagged. This appearance will be explained below, when we consider the growth of the bone.

Turning now to the bone-cells and the spaces in which they lie—the lacunæ—we find that some other mode of preparation is necessary than that of mounting sections of decalcified bone in glycerine, because the whole extent of the cell-spaces is not revealed, on account of their partial filling by the mounting medium.

If, however, we take a bone which has been macerated and dried, to remove the fat and other soft tissues, and prepare thin sections by grinding and polishing them, and then mount them in hard balsam, which is melted, and, after the section is enclosed, cooled so quickly that it does not have time to penetrate far into the tissue, the full extent of the cell-cavities is revealed. For all the spaces are now filled with air, which gives them a dark

appearance by transmitted light. In a section thus prepared (Fig. 487), it will be seen that the lacunæ are elongated, mostly fusiform, irregular cavities, lying between and in the lamellæ, and that from these minute branching canals, called *canaliculi*, pass off, piercing the lamellæ and forming frequent communications with the canaliculi of neighboring lacunæ. The canaliculi which pass out from the lacunæ lying near the Haversian canals pierce the walls of the latter and open into them. The canaliculi of neighboring Haversian systems, however, do not, as a rule, communicate with one another.

In the lacunæ, as may be seen in carefully prepared thin sections of decalcified bone, lie the flattened and, in some cases, branching bone-cells. To what extent the branches of the cells pass into the canaliculi is not yet fully established. The bone-cells have large nuclei and finely granular bodies.

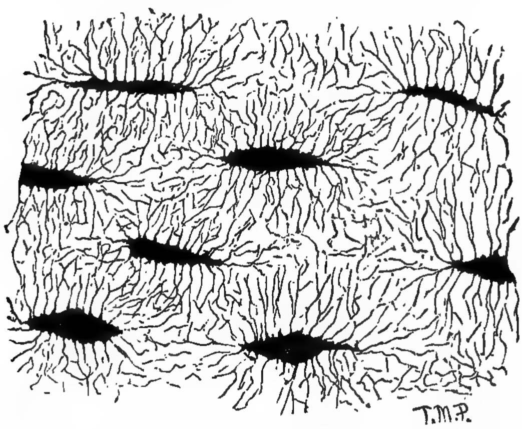


FIG. 487.—Longitudinal Section of Hard Bone, Human Humerus, Mounted in Hard Balsam. (× 300 and reduced.)

According to v. Ebener, Sharpey, and others, the basement substance of bone is not homogeneous, but is permeated by exceedingly minute decussating fibrils, similar to those of the basement substance of ordinary fibrillar connective-tissue. Certain of the lamellæ, particularly those of the circumferential and intermediary systems, are pierced by bundles of delicate fibrils, which pass perpendicularly or obliquely through them. These fibre-bundles, called *Sharpey's fibres*, may be seen projecting from the inner side of small bits of bone torn forcibly away from one another, near the surfaces of decalcified bones (Fig. 488) as well as in very thin sections. These Sharpey's fibres, as will be seen when we come to the development of bone, are the remains of the old fibrillar connective-tissue matrix in which the bone is formed.

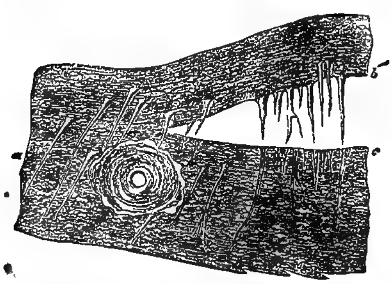


FIG. 488.—Section through the External Table of a Decalcified Human Parietal Bone. *a*, Sharpey's fibres in their natural position; *b*, fibres which have been pulled out of the underlying basement substance, *c*. (After H. Müller.)

The periosteum is a fibrous sheath surrounding the bones, except over their articular surfaces. It consists of moderately dense layers of fibrillar connective-tissue containing numerous blood-vessels, which ramify in the outer portions and finally enter the bone through the Haversian canals. There is a considerable number of elastic fibres in the inner portions of the periosteum, and it contains an abundant system of lymphatic vessels. In the growing bone irregular layers of large granular cells, called osteoblasts, lie in the inner layers of the periosteum, and between it and the bone. The periosteum contains a few nerves, which chiefly pass from it into the bone-tissue.

The marrow is a complex tissue which fills the large central cavities in the shafts of the long bones, the spaces in the cancellous tissue, and the larger Haversian canals. Marrow-tissue varies considerably in its appearance and structure in adults and in the young, as well as in different bones in the adult. In the adult the marrow in the shafts of long bones consists of blood-vessels and a delicate connective-tissue reticulum which supports a great abundance of fat-cells and a varying number of small spheroidal cells scattered between the fat-cells. Such marrow has a yellow appearance from the fat which it contains. In the cancellous tissue of both long, irregular-shaped, and short bones in the adult, and in all of the bones in young animals, the marrow is red in color, and contains comparatively few fat-cells. Red marrow consists, like the yellow marrow, of blood-vessels, lymph-vessels, and a delicate reticular framework whose meshes are more or less filled with cells. These cells are of several kinds (see Fig. 489.) There are abundant small spheroidal cells with nuclei, which are very large in proportion to the size of the cell body; and between these and considerably larger cells, also with large and often irregularly shaped and sometimes double nuclei, there are numerous intermediate forms. All of the above forms are very abundant in red marrow, and constitute the *marrow-cells* proper (Fig. 489, *A*). Then we find, much less frequently, and in varying numbers in different bones of the same animal, and in the bones of different animals, much larger, usually multinucleated cells, the so-called *myeloplaxes*, or giant-cells (Fig. 489, *B*). These myeloplaxes, although always large, vary considerably in size and shape, and in the number of their nuclei. The nuclei are apt to be collected in a compact mass near the centre of the cell, and often present quite bizarre and indescribable shapes. Finally, red marrow contains, in varying numbers, small nucleated cells, which bodies have the color and general appearance of red blood-cells, the so-called *nucleated red blood-cells*, and small spheroidal cells whose bodies contain larger and smaller particles of pigment, and a moderate number of fat-cells.

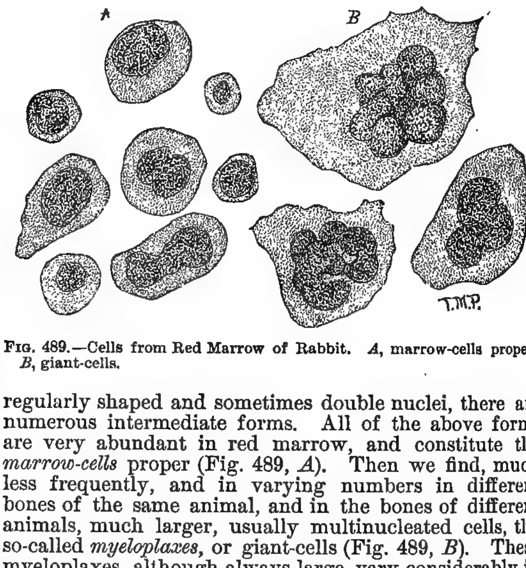


FIG. 489.—Cells from Red Marrow of Rabbit. *A*, marrow-cells proper; *B*, giant-cells.

THE DEVELOPMENT OF BONE.—It will be possible within the limits of this article to give only a very brief general description of the somewhat complex way in which bone is formed. It is customary to describe the development of bone as occurring in three ways, or, speaking more correctly, to describe three phases of bone development. These are *intracartilaginous, intramembranous*, and *subperiosteal*. It should be borne in mind, however, that the essential nature of the process is the same in all.

Intracartilaginous Ossification.—Most of the long and irregular-shaped bones in the body consist, at an early period of life, of masses of hyaline cartilage, which present, in a general way, the shape of the future bone. The transformation of these cartilage masses into bones

is intracartilaginous ossification. This is always associated with a certain amount of subperiosteal ossification in the manner to be described below.

If we look at one of the cartilage masses which is to be converted into a long bone—at one of the bones of the finger or toe, for example (Fig. 490, *A*)—at a period when the process of ossification is about to commence, we notice that at the central portion of the mass the cartilage-cells are larger (Fig. 490, *A*) than in other parts, and closer together, and that the basement substance between them is finely granular from the deposition in it of salts of lime. While this preliminary calcification of the cartilage and the enlargement of its cells is going on, a shell of bone is forming around the middle of the shaft beneath the periosteum, and as the cartilage near the ends continues to grow and expand at the sides, the entire mass assumes somewhat of an hour-glass shape. Now the blood-vessels from the perichondrium—which has become a periosteum on account of the above-mentioned shell of bone which has been formed around the shaft—begin to advance in the central portion of the cartilage, and this becomes channelled out in irregular branching canals in the region of the enlarged cartilage-cells, so that after a time a considerable portion of the central part of the shaft of the bone is permeated by a series of vascular canals. The general appearance of the bone at this time is seen in Fig. 490, *B*.

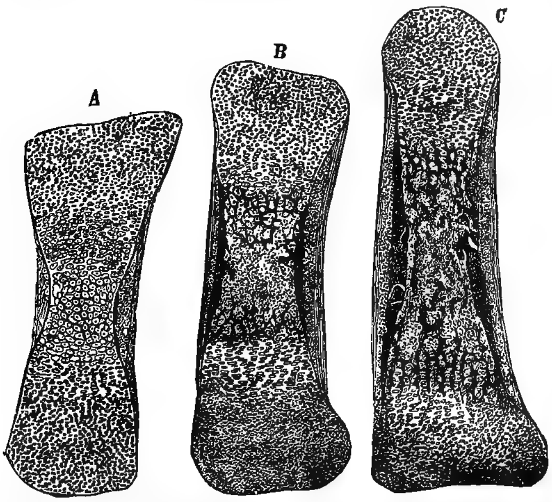


Fig. 490.—*A*, metatarsus of the great toe from human embryo ten weeks old; *B*, middle phalanx of the fourth finger of a human embryo fourteen weeks old; *C*, first phalanx of the little finger of a human embryo fourteen weeks old. (After Toldt.)

A closer examination at this period will show: 1, that the cartilage cells which lie in the region just beyond the advancing vascular canals have assumed a peculiar arrangement and are large; 2, that the basement substance of the cartilage in the same region is calcified; and 3, that thin layers of new bone are beginning to form along the edges of the vascular canals in the central portion of the shaft.

If we look at a similar bone at a somewhat later period, we find that while a layer of subperiosteal bone-tissue of considerable thickness has been formed round the shaft, the central portions of the structure are also filled with irregular bony trabeculæ, between which lie the vascular canals or marrow-cavities (Fig. 490, *C*); and, furthermore, that the cartilage-cells toward the ends of the bone, in the region just in front of the advancing marrow-cavities, are, as before, large, and arranged in rows and lie in a calcified basement substance.

It is now necessary to look more closely at the changes in the cartilage which precede the ossification, and to study the exact way in which bone-tissue is formed along the walls of the advancing marrow-cavities.

If we look with a high power at a thin section of a carefully preserved and decalcified bone in the process of development, confining our attention for a moment chiefly to that region which lies along the ends of the above-described advancing marrow-cavities, and for a short distance on either side, we find a condition similar to that represented in Fig. 491. At some distance toward the end of the bone from the medullary cavities the cartilage-cells become flattened and are arranged in irregular rows, *b*; nearer the ossifying portions of the bone the cartilage-cells are larger and more closely packed together; and finally, just beyond the ends of the advancing marrow-canals, large cartilage-cells are seen lying in elongated cavities in the basement-substance, *c*. Each cavity contains several cells, which, in many cases, are separated from one another by narrow partitions of cartilage basement-substance. Here and there along this region it will be seen that the marrow-canals with their contained blood-vessels have opened into and become continuous with the spaces containing the large cartilage-cells, and the latter have either disappeared or have assumed some different form. This occurs sooner or later, and usually at about the same time, all along this region, so that the advancing blood-vessels convert the spaces originally containing cartilage-cells into vascular canals or marrow-cavities.

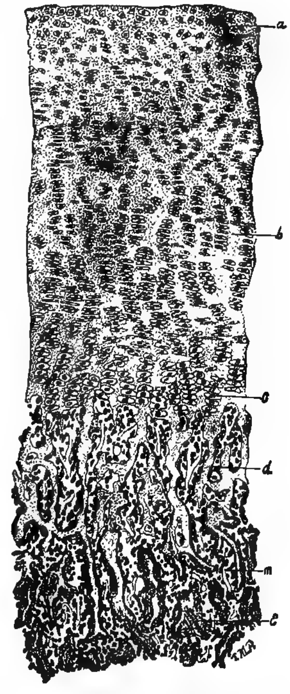


Fig. 491.—Longitudinal section of one of the Long Bones of the Foot of a Fœtal Pig, Eight Inches Long. (× 300 and reduced.) *a*, Zone of normal cartilage; *b*, zone of cartilage-cells in rows; *c*, calcification zone; *d*, zone of commencing ossification; *e*, masses of new-formed bone; *m*, marrow-cavities.

If we look now at the region near the ends of the marrow-canals, we find that these canals contain thin-walled blood-vessels, numerous small spheroidal cells, and larger cuboidal, ovoidal, or fusiform granular cells, which are apt to be arranged along the sides of the canals. These latter cells are the so-called *osteoblasts*, under whose influence the bone-tissue is formed.

The exact way in which the bone-tissue is deposited under the influence of the osteoblasts may be readily seen in very thin sections through the zone of ossification, which have been stained double with hæmatoxylin and eosine (see article on Microscopical Technology) and mounted in balsam. A small portion of such a section made transversely across the bone is represented in Fig. 492. Just beneath the osteoblasts which lie along the edges of the marrow-canals thin crescentic shells of strongly refractile calcareous material—the basement-substance of bone—are formed, *c*. These shells grow thicker and thicker, and rise up around the sides of the osteoblasts. They are pierced by delicate canals, which are to form the canaliculi. Gradually the entire osteoblast, which has become somewhat flattened and jagged in outline, is enclosed by the bony basement-substance and becomes a bone-cell. This process goes on around the osteoblasts, which lie side by side all along the walls of the marrow-spaces, so that the latter are presently enclosed by an irregular wall or encasement of new bone, *d*. Upon this new layers are deposited, so that gradually the marrow-spaces grow narrower and narrower, and finally contain only blood-vessels and a few marrow-cells. This gradual bony thickening of the walls and

narrowing of the marrow-spaces may be seen by following the tissue in a longitudinal section from the line where ossification commences, near the distal ends of the marrow-spaces, toward the centre of the bone where the process is oldest.

The fragmentary remains of the old basement-substance of the hyaline cartilage persist for some time, surrounded by the new-formed bone (see Fig. 492, *a*); but they grow smaller and smaller as more bone is formed, and are finally absorbed and altogether disappear.

Thus the ossification of the cartilages advances toward their ends, preceded always by a rearrangement and proliferation of the cartilage-cells, and by calcification of its basement substance. What the exact purpose is of the temporary calcification of the cartilage basement-substance just in advance of the ossification line, we do not know, nor is it certain what becomes of the cartilage-cells when the vascular canals finally open into the spaces in which they lie. Some observers believe that they disintegrate and are absorbed; others, that they become osteoblasts, or other marrow-cells. Equally uncertain is the origin of the osteoblasts, and the consideration of the more or less well-founded conjectures as to their genesis would lead us beyond the scope of this article.

After a time new centres of ossification are formed near the ends of the long bones, in the epiphyses, from

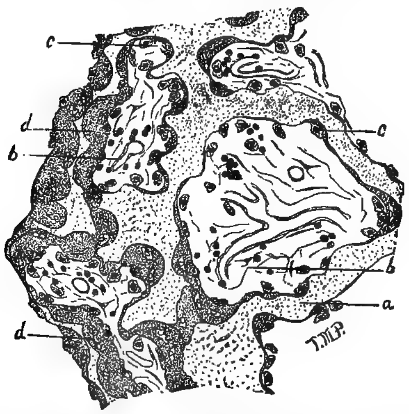


FIG. 492.—Transverse Section of Ankle-bone of Fœtal Pig, Eight Inches Long, through the Zone of Ossification. (× 300 and reduced.) *a*, Old cartilage basement-substance; *b*, marrow-spaces, containing blood-vessels and variously shaped cells, the larger of which are osteoblasts; *c*, osteoblasts partially enclosed by shell of bone formed beneath them; *d*, irregular masses of new-formed bone, containing the enclosed osteoblasts or bone-cells.

which bone-formation proceeds in the manner above described. At length the zones of ossification in the epiphyses and diaphyses approach one another, and are separated only by a narrow band of cartilage, which finally itself becomes ossified, and the epiphysis and diaphysis are joined to form a single bone.

Intramembranous and *subperiosteal ossification* vary only in details from the intracartilaginous. In the former case, the tissue in which bone is to form is fibrous and vascular; osteoblasts appear along the bundles of fibres which become calcified, and bone is formed around them in the above-described manner. Some of the fibrous bundles persist within the new-formed bone, as Sharpey's fibres. The bone-tissue which is at first formed is arranged in irregular trabeculæ, which cross and interlace as did the connective-tissue fibres which it replaces, and encloses irregular vascular spaces or marrow-cavities, which become smaller and smaller as successive layers of bone are formed around their sides (Fig. 493). After a time the irregular trabeculæ and their enclosed marrow-spaces become covered in by more uniform layers of bone. These, in the long bones, are the circumferential lamellæ, and in the flat bones, such as those of the skull, are the compact external and internal tables which enclose the diploë.

A pure intramembranous ossification is seen in the early stages of the formation of the flat bones of the skull. The subperiosteal ossification, on the other hand, occurs as above indicated, simultaneously with the intracartilaginous bone-formation in the long bones, as well as at a later stage in the formation of bones which are originally laid down as membranes.

GROWTH OF BONE.—The growth of bones when they are once formed, either in membranes or cartilages or beneath the periosteum, is a somewhat complex process. They increase in thickness by a continued subperiosteal ossification. The increase in length of long bones goes on by the ossification in cartilage until, as above stated, the epiphysis is finally joined to the diaphysis.

The large central marrow-cavity of long bones, which in the adult bone is itself much larger than the entire bone at an early stage of development, is formed by the absorption of the earlier developed intracartilaginous and subperiosteal bone. This absorption occurs under the influence of large, irregular-shaped, frequently multinuclear granular cells, called *osteoclasts*. Around these cells, as they lie against the bone-tissue, the latter becomes absorbed in some way, so that little pits are formed in which they lie. These pits or depressions, which are of various sizes and shapes, are called *Howship's lacunæ*. On the side of the osteoclasts which lie against the bone there is, according to Kölliker, a shining striated border. The

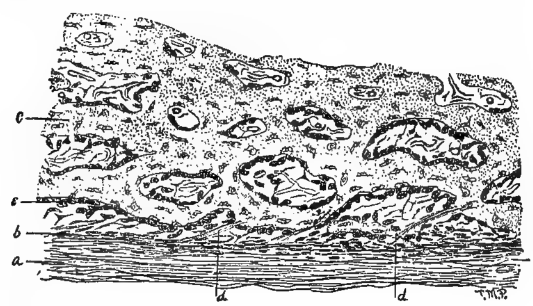


FIG. 493.—Subperiosteal Ossification from Leg of Young Rabbit. (× about 350 and reduced.) *a*, Periosteum; *b*, inner cellular layer of periosteum; *c*, irregular trabeculæ of new bone; *d*, Sharpey's fibres partly enclosed by bone; *e*, osteoblasts lining marrow-cavities.

exact nature of the influence by which the osteoclasts induce the absorption of the bone is not well understood.

Not only are the central marrow-cavities formed under the influence of the osteoclasts, but by an absorption of the bone in various places, and a subsequent new formation of it over the absorbed surfaces, a remodelling of the bone may occur, inducing the various changes in shape which growing bones present. This process of absorption and redeposition of bone goes on, not only on the surfaces, but in the substance, even of compact bone, during early and adult life, inducing the minor changes which occur at this period. The intermediary systems of lamellæ, above described, as seen in transverse sections of long bones (Fig. 486), are, in many cases at least, the remains of older lamellæ which have been partially absorbed; the absorption spaces having been afterward filled in by new Haversian systems. What the conditions are whose fulfilment determines now an absorption and again a new formation of bone, or exactly what the origin of the osteoclasts is, and what their relation to the osteoblasts, we can, in the present state of exact knowledge, do little more than conjecture.

Consult, for the bibliography of the histology, development, and growth of bone, Quain's "Anatomy," vol. ii., p. 116, ninth edition, and the "Index Catalogue of the Library of the Surgeon-General's Office, U. S. A.," vol. ii.

T. Mitchell Prudden.

BONE (PATHOLOGY). The aim of the present article is not to describe in detail all the forms of disease to which osseous tissue is liable, but rather to present a brief résumé of the subject, a sort of catalogue, as it were,

of bone affections, merely sketching the salient points in the symptomatology of the various diseases affecting the bony framework of the body. For an extended description of their etiology, pathology, and treatment, the reader is referred to the following articles: Osteitis, Osteomyelitis, Necrosis, including Caries, Periostitis, Rachitis, and Osteomalacia. Tumors of bone will be found described in the general article on Tumors, and the osseous manifestations of the syphilitic and tubercular infections will be treated of at sufficient length under the headings of Syphilis and Tuberculosis.

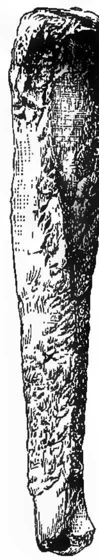


Fig. 494.*

The bones are subject to the same diseases as are the soft parts, but the morbid processes are less rapid in their action, as a rule, and present other differences depending upon the peculiar constitution of this tissue.

Periostitis is an inflammation of the periosteum, or enveloping membrane of bone. It may be acute or chronic, the symptoms of the two conditions differing chiefly in their intensity and rate of progress. It occurs as the result of injury, as one of the manifestations of the syphilitic, rheumatic, or gouty poisons, or as an accompaniment of inflammation of the subjacent osseous substance. The disease is indicated by the presence of a tense, somewhat elastic, circumscribed swelling; a node, tender on pressure, and usually the seat of a constant aching pain which is increased at night. The skin over the part is usually more or less hot and œdematous, but is not often discolored. The occurrence of suppuration is indicated by increased pain of a pulsating character, and often by rigors and other constitutional symptoms.


Fig. 495.

Acute diffuse periostitis is an inflammation of a severe type, involving the greater part, or the whole, of the periosteal covering of a long bone. It is characterized by a hot, painful swelling, not limited to a small area, the skin covering which is red, stretched, and shining. In most cases deep fluctuation can be detected early in the course of the disease, but this is sometimes obscured by the surrounding œdema, and by the tenseness of the periosteum. In the early stages the appearance presented resembles that of acute cellulitis, but the inflammation is always limited to one segment of the limb, and never passes over the joint. The constitutional symptoms are of a very grave character. Acute diffuse periostitis is often fatal, and when recovery does ensue, the stripping up of the periosteum almost always leads to necrosis of a greater or less extent of bone-tissue.

Osteitis is, strictly speaking, an inflammation limited to the bone substance, but in most cases the periosteum or the medulla becomes secondarily involved. It may occur from traumatism, but is, perhaps, more frequently of tubercular or syphilitic origin. It occurs secondarily in acute diffuse periostitis, and, when affecting the articular ends of long bones, may follow upon chronic fungoid (tubercular) synovitis. There is an enlargement of the affected portion of bone, less circumscribed usually than in simple periostitis, with deep-seated, constant pain, worse at night, as the pain in all bone diseases is apt to be. When the disease is seated in the end of a bone and involves the articulation, the joint motions are restricted by reflex muscular spasm. Osteitis usually terminates in necrosis or caries, bone-abscess, or sclerosis.

a

Fig. 496.

Bone abscess, or circumscribed suppuration of bone, is situated with greatest frequency in the head of the tibia. The collection of pus is usually small, and may escape detection until it has penetrated the articular surface and opened into the joint. The formation of a circumscribed abscess may be suspected when there is an intermittent, aching pain, limited to a small area, coming and going without any regularity, but usually worse and more persistent at night.


Fig. 497.

Osteomyelitis is an inflammation, primarily, of the endosteum, or medullary investing membrane. It is, however, never limited to this membrane, but involves the medulla and cancellous portion of the bone, and is also accompanied with extensive osteitis of the denser tissue. It occurs with greatest frequency after compound fractures, or operations involving the medullary portion. The symptoms are those of osteitis, but greatly intensified. The limb is red, hot, and swollen, and profuse suppuration occurs early. The pain is of the most intense character, and may exist some time previous to the appearance of swelling. There are rigors, high fever, and depression. The prognosis is very grave.

Necrosis is the death of osseous tissue in mass, gangrene of bone. It affects chiefly the compact portion, while caries is more prone to attack the cancellous structure. It occurs in consequence of injuries, after periostitis with separation of any considerable portion of the membrane, from the action of the syphilitic and other poisons (*e.g.*, phosphorus), by extension of inflammation from the neighboring parts, in senile degeneration, and from any other causes producing lowered vitality of the tissues. The symptoms are those of osteitis, viz., œdematous swelling with redness of the skin, enlargement of the bone, and pain. Abscesses form and discharge large quantities of pus. After a time the soft parts become indurated, and are traversed by numerous, often tortuous, fistulous tracts leading down to the sequestrum. These may exist and continue to discharge for years, unless the dead portion of bone is removed by operation.

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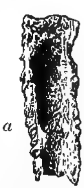
Fig. 498.

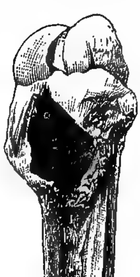
Fig. 499.

Caries is ulceration, or the molecular death of bone. It may occur in any situation, but is most frequent in cancellous bone-tissue, as, for example, in the articular ends of the long bones, or in the bodies of the vertebræ. The causes producing this condition are similar to those of necrosis. Caries is very frequently of tubercular origin. The carious process may go on without the formation of an abscess, in which case it is known as dry caries, or caries sicca. In the suppurative form occurring in the epiphyses or phalanges, there are the usual symptoms of osteitis, viz., pain, redness, and swelling. Abscesses form, and, opening, discharge pus mixed with bony detritus. The resulting sinuses remain open, discharging as long as the disinte-

* The cuts used in this article are copies of photographs kindly furnished by Dr. William Oldright, of Toronto. The specimens from which they were taken are in the Museum of the Toronto School of Medicine.

Explanation of Cuts.—"Figs. 494 and 495 are taken from the same specimen; Fig. 496, another portion of the same bone. They are portions of a tibia in which there has been inflammation of the entire bone and periosteum. Fig. 494 is a view of the exterior, showing extensive deposit of osseous material. Fig. 495 shows a section of the same made antero-posteriorly; toward the edges, especially posteriorly, the tissue is seen to be dense, compact, and hard—sclerosis; this tissue is about one and a half inch thick. The bone is very heavy in consequence. The central portion is soft and friable. The dark spots show cavities—pus cavities—this result having been assisted by the cutting off of blood-supply by the sclerosed exterior. In Fig. 496 the fellow, or portion which was apposed to the upper part of Fig. 495, the same condition is seen, and at *a*, (or rather, at the dark spot opposite *a*) is the *cloaca* through which the pus escaped. Figs. 497 and 498, representing outer and inner views of the same bone, are also beautiful specimens. Fig. 497 shows bunchy or fleecy deposits of bone material; in Fig. 498 the osteo-myelitis is shown to have predominated, the bone being hollowed out; the line of division between the original bone surface and the new deposit is beautifully shown at the point opposite the letter *a*. Fig. 499 represents a cystic cavity in the head of the tibia; no history is obtainable."—W. O.

grative process continues, or they may close and new openings occur in the neighborhood. When caries attacks the bodies of the vertebræ, the abscess may open in the back alongside of the spinal column, but more commonly the pus enters the sheath of the psoas muscle, and eventually forces an opening in the groin or thigh. Caries in this region, if at all extensive, results in the production of a kyphos from the breaking down of the vertebral bodies.

Rachitis is a general disease of malnutrition, one of the manifestations of which is softness of the bones from a deficiency in the proportion of their earthy ingredients. It is a disease of early childhood, and affects chiefly those living under bad hygienic conditions. The bones are wanting in firmness, and become bent from the force of gravity, or as a result of muscular action. In the latter stage of the disease, ossification proceeds with great rapidity, and exceeds the normal limits, producing a condition of eburnation. The mechanical treatment of rachitic deformities (knock-knee, bow-legs, kyphosis, etc.) should therefore be undertaken early, before the bones have become consolidated, and while they are yet flexible.

Osteomalacia, or mollities ossium, is a disease of adult life, especially prone to attack females during the period of pregnancy or lactation, although males are not wholly exempt. The cause is obscure. The disease is characterized by a decalcification and central absorption of the bones, which then become distorted, or break from muscular action or other slight causes. The softening of the bones is usually preceded by a period during which various obscure rheumatoid pains are complained of; the pains are usually worse at night, but are not characteristic of the disease in question. The general health is not usually affected until late in the disease, and even then only secondarily, by reason chiefly of the impeded respiratory movements from the softened ribs. Recovery from osteomalacia very rarely occurs.

Sir James Paget has described a disease under the name of local osteomalacia, or osteitis deformans, which bears some resemblance to the affection just considered, although it is pathologically an osteitis. The bones become somewhat enlarged, and sufficiently softened to permit of bending under the weight of the body. There may be severe pains in the limbs, and these are soon followed by deformities resembling those of rickets. The legs are bowed, and the spine becomes kyphotic, so that the head projects forward. There are often curvatures of greater or less degree in the other bones also. The general health is usually unaffected. It has, however, been observed that sufferers from this disease frequently become the subjects of carcinoma. It is a very rare affection.

Fragilitas ossium is a term employed to denote a condition in which fractures occur from slight causes, or even from no cause at all other than the normal strain put upon the skeleton in walking, and by ordinary muscular action. This brittleness of the bones may be due to fatty degeneration, mollities ossium, or senile atrophy, and there would seem in some cases to be a sort of idiosyncrasy, the nature of which is not yet determined, but which is distinct from the conditions just mentioned. Union generally occurs promptly after spontaneous fracture. The bones may be weakened by necrosis, hydatid cysts, and cancer, especially central, round- and spindle-celled sarcoma; but the conditions are here local, and spontaneous fracture so occurring could not properly be referred to fragilitas ossium.

Tumors.—The new growths of bone are very similar to those attacking the soft parts, and, like them, are benign or malignant in their nature, though it is sometimes impossible to determine with which we have to deal in a given case.

Enchondromata are usually found on the phalanges and metacarpal bones, though occasionally also on the scapula, pelvic bones, and other parts of the skeleton. Their growth is slow and usually painless, but they often attain a large size. Cartilaginous tumors are usually nodulated and hard, though elastic.

Exostoses are not uncommon about the orbit, and when on the extremities, are usually situated at the junction of the shaft with the epiphysis. They may be pear-shaped or with a broad base, and are often nodulated or irregular in contour. Sometimes their growth is unattended with pain, but they often give rise to persistent aching. A favorite seat of exostoses is the ungual phalanx of the great toe, and, when in this situation, they cause excessive pain and disability. Exostoses not infrequently arise from ossification of enchondromata, and tumors are often seen in which the two tissues exist together in varying proportions. Allied to exostoses are the osteophytes, situated at the points of origin and insertion of the muscles.

Myeloid tumors are peculiar to bone. They are usually situated at the articular extremities of the bone, especially of the femur and tibia, but may grow in the shaft. They arise from the endosteum and medullary portion, and expand the bone in their growth, forming rounded, elastic tumors, which when pressed upon sometimes impart a crackling sensation.

Bone cysts are either serous, sanguineous, or hydatid, the latter being of very rare occurrence. Cysts are usually slow and painless in their growth, and present the appearance of smooth, rounded tumors, elastic, and crackling when pressed upon.

Sarcomata are of endosteal or periosteal origin. They are usually of rapid growth, often very painful, forming tumors of a somewhat globular or more or less ovoid shape, elastic, and usually ossified in portions of greater or less extent.

Pulsating tumors of bone are generally of malignant nature. They are to be distinguished from true aneurism, which is, however, of exceeding rarity.

Atrophy of bone may occur from senile wasting, in rachitis or osteomalacia, as a result of fracture, or from other undetermined causes. Arrested development may occur without any apparent morbid process; it is seen with greater frequency in the scapula or sternum than in the long bones. In infantile paralysis (anterior poliomyelitis) the growth of the bones of the affected limb is often retarded, but to a less extent than are the soft parts. Another form of atrophy consists in a wasting away of the compact bone-substance from the centre toward the periphery, until simply a thin cylinder of osseous tissue remains, the central portion being occupied by the increased medulla. Fatty degeneration may also occur in bone as in other tissues.

Hypertrophy may occur without apparent cause, may result from hyperæmia incident to local disease, or may be compensatory, as when the fibula becomes thickened in order to perform the functions of a tibia weakened by necrosis. The bones of the skull may become thickened in connection with shrinkage of the cranial contents. In old age the diploë between the outer and inner tables of the cranial bones often becomes converted into condensed osseous tissue. There is sometimes a disproportion in the length of the bones of the leg occurring without any apparent cause. In such cases the lengthened bone may become bowed, or it may remain straight and cause a form of talipes, as in a case, seen by the writer, in which the fibula was the hypertrophied bone. If one femur is lengthened a disproportion in the length of the lower extremities results which may be a source of error in measuring after fractures or in chronic joint disease. Sclerosis of a bone may result from disease, the condensing osteitis of Volkmann, or there may be an actual increase in diameter from osteitis interna.

Syphilis.—The bone affections are among the later manifestations of syphilitic disease, though gummy tumors have in rare instances been observed among the early symptoms. There is usually deep-seated pain, worse at night and sometimes felt only after sunset. The affections may be divided into periosteal and osteitic. In the former there are circumscribed effusions under the periosteum giving rise to nodes. The swellings are hard and tense, feeling almost like bone, though usually more or less elastic, or they are very soft and fluctuating, simulating abscesses (gummata). The bone beneath these nodes is sometimes normal and sometimes sclerosed. The subperiosteal effusions may be absorbed, become ossified or softened. When softening occurs it may lead to caries and destruction of the underlying osseous tissue. Oste-

itis occurring in the tertiary period may eventuate in hypertrophy and sclerosis, or there may be extensive caries unaccompanied by suppuration.

Tubercular and scrofulous bone disease is marked by inflammation of low grade and slow course. It affects chiefly the articular extremities. There is usually an indolent swelling, with, perhaps, œdema of the parts, the overlying integument being pale. There is pain, sometimes very acute, usually worse at night. Tubercular osteitis is very prone to become suppurative, the purulent secretion often being excessive. *Thomas L. Stedman.*

BONE-SETTING. In every country there is a class of irregular practitioners who make a living, and sometimes also quite an extensive reputation, by their success in restoring functional usefulness to crippled limbs. These individuals are, as a rule, most arrant quacks, knowing absolutely nothing of anatomy, or of the pathology of the conditions which they are called upon to treat, and yet are often successful to a remarkable degree in curing certain joint affections which may have baffled the skill of the most experienced and able surgeons. These men are known as bone-setters, from their invariable assertion, made often through honest ignorance, that "the bone is out of joint, and only needs to be set." It is true that they frequently inflict most serious injury, which may lead to loss of limb or life itself, yet it is also undeniable that they sometimes restore a limb which might otherwise remain permanently crippled, or even be sacrificed as a useless incumbrance. Such being the fact, it is not the part of wisdom to seek to ignore the existence of bone-setters, or to allow their failures to blind our eyes to their successes; but we should rather study their methods, to learn wherein lies the secret of their triumphs, and then we may with benefit and without any loss of dignity imitate their treatment in suitable cases, easily avoiding, through a knowledge of anatomy and pathology, the pitfalls into which they, in their ignorance, so often plunge.

Dr. Wharton P. Hood[1] was the first to study intelligently the methods employed by bone-setters, and it is to him that most of our knowledge of this art, for art it is, though no science, is due. He defines bone-setting as "the art of overcoming, by sudden flexion or extension, any impediments to the free motion of joints that may be left behind after the subsidence of the early symptoms of disease or injury; perhaps, indeed, more frequently of the latter than of the former." The cases that most frequently fall into the hands of bone-setters, and are cured, to the joy of the patient, but to the discredit and loss of reputation of the regular practitioner, are those of slight fibrous anchylosis, of a degree sufficient to limit motion and impair the functional utility of the limb, yet not such as apparently to demand forcible rupture, an operation so unreasonably dreaded by many surgeons. In such a case, perhaps, some feeble attempts at passive motion are made. The joint is flexed cautiously and slowly, until the patient complains bitterly of pain; then the operator desists, orders the limb to be kept at rest, and bathed with lotions to subdue the inflammation excited by the strain put upon the adventitious bands. A few days later, when the heat and swelling have disappeared, the same manipulations are repeated, and followed again by inflammation and its treatment. After a number of repetitions of this sort the patient sees that he is no better than before, and refuses to submit his joint to any further manipulations. Then he becomes discouraged, limps around with the aid of a cane or crutches, and tries to bear philosophically the thought that he is a cripple for life. But at last some friend tells him of a wonderful cure performed by a bone-setter in a case apparently similar to his own, and in desperation he sends for the quack. The latter assures him that the bone is out and only needs to be replaced. He orders the joint to be enveloped for a time in flax-seed poultices, probably a procedure that contributes in no way to the success of the operation, and then on the appointed day meets his patient, seizes the limb, and with a quick motion flexes and extends the joint to its full extent, breaking up all the adhesions, and the patient finds that he is cured. The pain of the operation is but little greater than that inflicted by the regular practitioner in his feeble and ineffectual attempts to restore mobility, and the resulting inflammation is usually slight or nil. The quack says that the bone is restored to its place, pockets his fee, and retires with glory.

This is no exaggerated picture, but is a true tale of what actually occurs in not a few instances, as many practitioners will sorrowfully admit. The good that bone-setters do is in these cases of partial anchylosis, and it is because they are unable to discriminate between the different conditions in which joint-motion is impeded that they so often inflict irreparable injury. No surgeon would attempt to forcibly move an articulation which is the seat of strumous or tubercular inflammation, yet this is what the bone-setter does with dire result. In most of the joints which can be benefited by forcible movements there is a tender spot, usually about the inner side, for which the bone-setter always feels, and the discovery of which is to him a sign of ultimate success. The motion of the joint is not absolutely abolished, but is limited in certain directions, and any attempt to pass this limit causes pain. The skin over the articulation is not hot, and all the other signs of inflammation, except perhaps a slight serous effusion, are absent. The following is an enumeration of the location of these painful spots, together with Mr. Fox's explanations of their occurrence, as given by Mr. Edward Cotterell in a recent very practical little work treating of the minor injuries of the limbs.[2] 1. "Over the head of the femur, in the centre of the groin, corresponding to the ilio-femoral band of the capsular ligament (which is most severely stretched when the thigh is over-extended, as when the trunk is flung violently backwards, the commonest cause of a sprained hip). 2. For the knee-joint, at the back of the lower edge of the internal condyle; in other words, at the posterior border of the internal lateral ligament, where it blends with Winslow's ligament, and where the semi-membranous tendon is in intimate relation with it. These parts suffer most because, as Mr. Morris says, 'during extension they resist rotation outward of the tibia upon a vertical axis, and a sprained knee is almost always caused by a twist outward of the foot.' 3. For the ankle, on the front of the external malleolus, the apex of the plantar arch, and the tip of the fifth metatarsal bone. 4. For the shoulder, at the point corresponding to the bicipital groove, because in nine cases out of ten a man sprains his shoulder to prevent himself from falling; his hand grasps the nearest support, the body is violently abducted from the arm, the long head of the biceps is called upon to exert its utmost restraining power, the bicipital fascia is over-stretched, and the tendon very often misplaced. 5. For the elbow, in front of the tip of the internal condyle; the fan-shaped internal ligament has its apex at that point, and it is most stretched in over-supination with extreme extension of the forearm. 6. For the wrist, the styloid process of the ulna, and the annular ligament in front of the wrist."

The injuries or diseases most likely to give rise to the slight degree of anchylosis which is amenable to the bone-setter's manipulations are rheumatism and gout, displaced tendons or cartilages, sprains, prolonged immobilization during the treatment of fractures, neuromimetic joint affections treated improperly by rest and mechanical support, and ganglions.

The bone-setter's manipulations consist in first locating the painful point, upon which the thumb is firmly pressed during the remainder of the operation; and then, while steadying the proximal segment of the limb, the distal segment is grasped and rotated as much as possible on its axis in order to overcome, as far as may be, muscular resistance; this being accomplished, the joint is sharply flexed or extended in the direction of greatest resistance, and then the reverse movement is made until all the adventitious bands are broken, or until the "bone is put back," in the bone-setter's own phraseology. The rupture of these bands of adhesion is often accompanied by a loud report. For a description of the special manipulations required for each joint, the reader may consult the work of Wharton Hood, above referred to.

It should not be forgotten that most of these stiff joints may be prevented by a proper attention to the treatment of minor injuries of the articulations, and this is one of the principal lessons which we may learn from the bone-setters. If surgeons would never dismiss a case of fracture or sprain until joint-motion were perfectly restored, the occupation of the bone-setter would be less lucrative than it now is. *Thomas L. Stedman.*

[1] On Bone-Setting (so-called), and its Relation to the Treatment of Joints Crippled by Injury, Rheumatism, Inflammation, etc. By Wharton P. Hood, M.D., M.R.C.S. London and New York, 1871.

[2] On Some Common Injuries to Limbs: Their Treatment and After-treatment, including Bone-setting (so-called). By Edward Cotterell, M.R.C.S., Eng., L.R.C.P., Lond. London, 1885.

BONES, TEETH, AND CARTILAGE. The bones of vertebrates consist of an organic basis of glutin or gelatin-forming tissue (osseïn) and calcium phosphate, with less quantities of magnesia, calcium carbonate, fluorine, and chlorine. The teeth have a similar constitution, but contain less organic matter. According to Volkmann the bones contain a mean of fifty per cent. of H_2O, fifteen to seventy-five per cent. of fat, twelve to forty per cent. of osseïn, and twenty-one to eighty-five per cent. of bone-earth. In the adult the quantity of osseïn is very constant in its proportion to bone-earth; the old and children have less.

The following analysis of bone is by Zalesky:

Bones of:	CaO	MgO.	P_2O_5	CO_2	Cl	F
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Man	52.83	0.48	38.73	5.73	0.18	0.47
Ox	53.89	0.47	39.89	6.20	0.20	0.62
Guinea-pig	54.03	0.48	40.38	....	0.13	....
Testudo græca	52.52	0.62	39.78	5.28	....	0.42
Fossil rhinoceros tooth enamel	....	....	....	....	....	0.59

Bone-earth has for its composition calcium phosphate, magnesium phosphate, calcium carbonate, magnesium carbonate, calcium chloride, and calcium fluoride; but how these constituents are connected with one another is not yet definitely known. Traces of cerium, lanthanium, and didymium have been found by Cossa. Pflügge could not find iron. According to Maly and Donath there is much evidence for the view that the osseïn of the bones is united with calcium phosphate chemically.

THE TEETH show, as far as their bony substance is concerned, a very similar composition to that of bone as found elsewhere.

The following table of Æby's shows at a glance the relation of enamel and bone:

Constituents.	In enamel.	In tooth-bone (dentine).
	Per cent.	Per cent.
Organic matters	3.60	27.70
3 $Ca_3P_2O_8$	93.35	91.32
CaO	0.86	5.27
$CaCO_3$	4.80	1.61
$MgCO_3$	0.78	0.75
F_2O_3	0.09	0.10
$CaSO_4$	0.12	0.09
	100.00	99.14

The following table of Hoppe-Seyler's gives various analyses of enamel:

Constituents.	New-born child.	Pig. Enamel not fully formed.	Pig. Enamel fully formed.	Dog.	Horse.	Elephant, fossil.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
3 $(Ca_3P_2O_8)$ + $CaCO_3$	82.40	89.09	94.30	93.91	93.40	91.03
$CaCl_2$	0.23	0.46	0.62	0.80	0.66	0.44
$MgHPO_4$	2.37	2.22	2.73		1.68	2.75
Soluble salts	0.35	0.24	0.15	} 6.81	} 4.74	......
Organic matters	15.59	9.71	2.06			4.54
	100.94	101.72	99.86	101.52	100.48	98.76

CARTILAGE.—Yields on boiling, as a final product, chondrin. According to v. Mering, gelatin and mucin are also to be found. Cartilage is very much poorer in mineral substance than the bones. The analyses of cartilage by v. Bibra give a very large proportion of calcium sulphate, part of which, the sulphuric acid, must be considered as arising by the oxidation of the sulphur of the organic substance during the ashing process. Potassium is found only in traces, sodium in moderate quantity. Iron has also been found in cartilage.

T. Wesley Mills.

BORAGE (*Bourrache*, Codex Med.), *Borago officinalis* Linn.; Order, *Boraginaceæ*. A European or Oriental plant, occasionally cultivated in flower-gardens in the United States. It has a succulent, branched, hairy stem, half a metre or so high (twenty inches), with rough, coarse-looking, entire leaves, and terminal one-sided cymes of pretty, blue flowers.

Borage has been a domestic medicine in Europe for years, and is still officinal in France. The leaves and flowers are used. The former are from ten to twenty centimetres (four to eight inches) long and half as broad, elliptical or lanceolate, tapering at the base; those of the stem, sessile, and embracing it. They are rugose and bristly hairy. The flowers are regular, open bell-shaped, or rotate, with a five-parted, hairy calyx, a five-cleft, beautiful, blue corolla, with folds at the throat, five stamens, and a two-carpelled, four-seeded pistil.

The odor of borage is slight, at least when dry; taste, bland and mucilaginous. It contains no more active principles than mucilage and nitrate of potassium, and its medical qualities are only those of a mild demulcent. An extract, a juice (*Suc*), and an infusion (*Tisane*) are to be found in the Codex.

ALLIED PLANTS.—The order is a large one, characterized by the peculiarities of the flower given above, by the hairy leaves and stems, and by its peculiar, one-sided inflorescence or "scorpioid" cymes. It comprises 1,200 species, generally mucilaginous and mild. A few are used as salads or food, a few are prized as flowers. The following genera have been or are in use:

1. The Heliotropes, *Heliotropium peruvianum* Linn., etc., cultivated everywhere for their delicious flowers.
2. Hound's tongue, *Cynoglossum officinale* Linn., mucilaginous, bitter, and nauseous, used as a pectoral, etc.
3. Comfrey, *Symphytum officinale* Linn., cultivated for its thick, mucilaginous (demulcent) root.
4. Borage.
5. Bugloss, *Anchusa officinalis* Linn., mucilaginous (demulcent).
6. Lungwort, *Pulmonaria officinalis* Linn., mucilaginous (demulcent) "pectoral."
7. Alkanet, *Alkanna tinctoria* Tausch, cultivated on account of its coloring matter, no physiological activity.
8. The pretty Forget-me-not, *Myosotis halustris*, often cultivated for ornament.

ALLIED DRUGS.—The mucilages in general. See ACACIA, Matico, Benné Leaves, Marsh Mallow, Irish and Iceland "Mosses," etc. *W. P. Bolles.*

BORAX SPRINGS, CALIFORNIA. *Location and Post-office*, Lower Lake, Lake County, California.

ACCESS.—By Central Pacific, California Pacific & Northern Division to Calistoga, by stage to Lower Lake, thence by carriage to Springs.

ANALYSIS (J. A. Veatch).—One pint contains:

	Grains.
Carbonate of soda	6.671
Carbonate of ammonia	8.613
Chloride of sodium	10.577
Iodide of magnesium	0.011
Biborate of soda	12.911
Alumina	0.157
Silicic acid	1.029
Matters volatile at red heat	8.221
	48.190

Gas.	Cub. in.
Carbonic acid	9.60

These waters are remarkable for the proportion of ammonia that they contain, being greater, it is thought, than in any other known Spring. Borax Lake, near by, has its jelly-like mud filled with crystals of the biborate of soda in the proportion of about eighteen per cent., and whence borax is manufactured at the rate of about three thousand pounds a day.

The Springs discharge three hundred gallons per minute, which is not utilized, as it would undoubtedly be, for the manufacture of commercial borax, were it not that two miles distant is the more abundant supply.

G. B. F.

BORDIGHERA. A small town lying on the Mediterranean coast of France about three miles west of the Italian frontier (Lat. 43° 50′ N., about), surrounded by extensive olive-tree plantations and celebrated for its grove of palms. The old town, consisting of a densely packed and crowded mass of houses intersected by narrow and dark streets, although strikingly picturesque to the eye of a traveller, is by no means suited for the residence of invalids. The new town, called New Bordighera, has grown up within recent years and is a mere collection of villas and hotels designed expressly for the latter use. From the peculiar character of its situation, Bordighera, or rather the newer part of the town, is said to possess a more distinctively maritime climate than is to be found at any other resort lying upon the Genoese Riviera. For figures representing the climate of the place, and for a fuller and more detailed account of the attractions which it presents as a place of winter residence for invalids, the reader is referred to the article entitled RIVIERA. *H. R.*

BORIC ACID. Boric acid (H_3BO_3), often called by the older but less correct name of *boracic acid*, is officinal in the U. S. Pharmacopœia under the title *Acidum Boricum*, Boric Acid. It is described as "transparent, colorless, six-sided plates, slightly unctuous to the touch, permanent in the air, odorless, having a cooling, bitterish taste, and a feebly acid reaction; in solution turning blue litmus-paper red, and turmeric paper brown, the tint, in the latter case, remaining unaltered in presence of free hydrochloric acid. Boric Acid is soluble in 25 parts of water and in 15 parts of alcohol at 15° C. (59° F.); in 3 parts of boiling water and in 5 parts of boiling alcohol" (U. S. Ph.). Although thus described as occurring in "transparent plates," commercial samples are more commonly in white, non-transparent, shapeless pieces.

Boric acid is, chemically, of very feeble acid power, and in its physiological relations is characterized by a marked absence of sour taste and quality—even a saturated solution being practically tasteless—and a corresponding nearly complete absence of irritant action upon even highly sensitive surfaces. Thus a cold saturated aqueous solution can be applied to the conjunctiva with scarcely more sensation than the tears themselves produce.

A few cases have been reported in which the copious use of boric-acid solutions upon raw surfaces has been followed by dangerous symptoms, and in two instances by death. These cases, however, were of severe procedures—in two instances the washing out of a pleural cavity, and in one the washing of the sac of a large lumbar abscess. In the absence of more extended experience, therefore, it would be rash to ascribe the untoward results in those cases to any specifically poisonous action of the boric acid. The symptoms were nausea, vomiting, hiccup, and heart-failure.

The medicinally valuable effects of boric acid hinge on a property that the drug possesses of being obnoxious to the development of the organisms that have to do with zymotic processes. The powers of boric acid in this regard have, however, been overrated. The experiments of Sternberg,[1] the most precise with which the writer is acquainted, assign to the acid the power of preventing the development of the micrococcus of pus in a one-half per cent. solution; but in the matter of *permanently sterilizing* such organisms—quite another story—the experiments record complete and repeated failure even in saturated (four per cent.) aqueous solution, and this not only in the cases of the micrococcus of pus, and that of septicæmia, but also in the case of the common *bacterium termo*.

Boric acid must therefore be regarded in the present state of knowledge as a fairly efficient antiseptic—convenient, withal, because odorless, tasteless, unirritating, and practically non-poisonous—but must *not* be relied upon as a germicide in the proper understanding of the term. Probably, largely because of its antiseptic action, boric acid, locally applied, tends to abate the catarrhal process, and is, for such application, again peculiarly agreeable because of the absence of irritation in its action. As a collyrium in conjunctivitis, a gargle in pharyngitis, or an injection in cystitis, solutions of boric acid are, therefore, often efficacious for cure, and always at least innocent of harm. For an application to catarrhal surfaces, or for antiseptic purposes to wound surfaces, boric acid may be used in aqueous solution ranging from one to four per cent. in strength—the latter being, indeed, at ordinary temperatures, a saturated solution.

Boric acid has also been given internally in doses of 2.00 Gm. (thirty grains) frequently repeated, with no poisonous effect, and with asserted benefit in dyspepsia with fermentation of the ingesta, in chronic cystitis, in diphtheria, and in other diseases probably determined by the multiplication, within the system, of microzymes. More experience, however, than as yet exists, is necessary before the exact efficacy of boric acid in these applications can be held to be established. *Edward Curtis.*

[1] American Journal of the Medical Sciences, April, 1883.

BORLAND MINERAL WELL, W. VA. *Location and Post-office*, Borland, Pleasant County, W. Va.

ACCESS.—From Wheeling or Parkersburg, via the Ohio River Railroad to Willow Island Station, thence by stage to the Springs, five miles distant.

ANALYSIS (Professor Wormley).—One pint contains:

	Grains.
Sodium chloride	30.009
Soda bicarbonate	14.024
Soda sulphate	4.734
Potash sulphate	2.828
Magnesium bromide	0.035
Magnesium iodide	0.003
Magnesium chloride	0.267
Lime bicarbonate	1.574
Magnesia bicarbonate	0.391
Alumina phosphate	0.029
Alumina and iron (as carbonates)	0.080
Manganese	trace
Silica	0.073
Organic matter	trace
Total solids per pint	54.047

The water has a perceptible quantity of sulphuretted hydrogen gas, and also some hydrocarbon gas.

THERAPEUTIC PROPERTIES.—This is a fine saline-sulphur water, and, although less renowned than some others, should prove equally as beneficial in that class of diseases to which an alkaline-salt-sulphur water, cathartic and alterative in its action, is adapted.

The well was struck, two hundred feet below the surface, twenty years ago, while boring for petroleum.

There are, as yet, no hotels, but visitors are comfortably provided for by the neighboring farmers. The location is healthful and the climate delightful.

G. B. F.

BOROGLYCERIDE. Under this title there has been introduced into medicine a compound formed by direct reaction of boric acid upon hot glycerin. In this reaction tribasic boric acid replaces the three hydroxyl equivalents of the molecule of glycerin, forming *glyceryl borate*, $C_3H_5BO_3$, with evolution of water, as per the following equation: $C_3H_5(OH)_3 + H_3BO_3 = C_3H_5BO_3 + 3H_2O$. Boroglyceride is a solid, vitreous body, transparent, and of a light amber color. It has little odor, and a slightly sweetish taste, with a faint astringent twang. It is hygroscopic, rapidly becoming sticky on exposure to the atmosphere. It dissolves freely in glycerin, and, melted

into an equal weight of that fluid, forms a permanent, viscid, clear solution. The solubilities in water and alcohol have been very variously stated. A sample tested by the writer broke up into opaque, granular flakes, by treatment with cold water, but finally dissolved in ten times its weight of that fluid; and in cold absolute alcohol it dissolved slowly but completely, in even less than its own weight, forming a clear, syrupy solution.

Boroglyceride is reported to be strongly antiseptic, and was originally proposed by Barff, before the Society of Arts of London, as an agent for the preservation of food-stuffs. Taken internally it has seemed to be as innocent as the two substances of which it is compounded. It has so far been used in medicine locally only, being applied —generally in glycerin solution—as a dressing to wounds, ulcers, catarrhal mucous membranes, etc. It is claimed to be at once antiseptic, astringent, and healing, while inodorous and practically unirritating. It is most commonly employed in fifty per cent. glycerin solution, or in ointment made by mixing one part of such glycerin solution, while hot, with three parts of vaseline.

As a preservative, boroglyceride has been recommended in solutions ranging from two per cent. to five per cent. in strength. *Edward Curtis.*

BOSTON. The accompanying chart, representing the climate of the City of Boston, Mass., and obtained from the Chief Signal Office in Washington, is here introduced for convenience of reference. A detailed explanation of this and of other similar charts will be found under the heading Climate; where also the reader may find suggestions as to the method of using these charts. *H. R.*

Climate of Boston, Mass.—Latitude 42° 21′, *Longitude* 71° 4′.—*Period of Observations, November* 1, 1870, *to December* 3, 1883.—*Elevation of Place of Observation above the Sea-level,* 18 *Feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	23.4	30.4	25.4	26.4	34.8	20.4	35.3	17.0	69.5	36.0	8.0	−13.0	21	29
February..	24.6	32.8	26.9	28.1	32.5	22.1	38.6	20.1	64.0	52.0	13.0	−6.5	22	18
March......	31.7	38.4	32.7	34.2	41.5	26.8	43.2	26.7	72.0	48.0	26.0	−7.5	21	20
April.......	41.8	48.7	41.4	43.9	47.2	37.0	53.2	36.1	85.0	66.0	34.0	11.0	21	18
May........	55.5	61.2	52.9	56.5	62.6	49.8	66.5	47.5	97.0	81.2	40.0	31.0	28	22
June........	65.0	71.6	62.0	66.2	69.0	60.6	76.2	56.4	98.0	86.4	51.0	44.0	19	19
July........	70.3	76.6	67.9	71.6	74.7	68.5	81.1	62.5	101.0	89.0	57.0	46.0	22	20
August.....	67.6	74.8	66.2	69.5	72.4	67.6	79.9	61.0	96.8	87.0	58.0	47.0	22	21
September..	59.9	67.3	59.2	62.1	65.7	58.8	72.7	55.2	101.5	79.0	49.0	34.0	23	18
October....	49.3	57.0	49.7	52.0	56.0	47.4	62.9	44.4	90.0	70.0	39.0	25.0	25	21
November..	36.5	42.9	37.4	38.9	43.2	32.8	49.2	32.8	75.0	55.0	27.0	−2.0	24	20
December..	26.9	33.1	28.7	29.5	37.8	21.9	40.3	23.8	66.0	47.0	14.0	−12.0	22	26
Spring......	......	......	......	44.8	48.8	42.4	......	......	......	......	......	......	......	......
Summer....	......	......	......	69.1	71.8	66.2	......	......	......	......	......	......	......	......
Autumn....	......	......	......	51.0	53.8	47.6	......	......	......	......	......	......	......	......
Winter.....	......	......	......	28.0	36.1	24.5	......	......	......	......	......	......	......	......
Year........	......	......	......	48.2	49.4	46.2	......	......	......	......	......	......	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind.*
						Inches.	From	Miles.
January...	82.5	71.8	10.2	7.8	18.0	4.03	N.W.	9.7
February..	70.5	69.6	8.9	9.3	18.2	3.52	N.W.	10.6
March.....	79.5	69.4	9.5	8.7	18.2	4.97	N.W.	11.3
April......	74.0	64.8	12.0	6.9	18.9	4.01	N.W.	10.0
May.......	66.0	64.1	14.2	7.4	21.6	3.48	S.W.	8.7
June......	54.0	67.8	11.9	7.7	19.6	3.63	S.W.&W.	7.7
July.......	55.0	69.7	13.9	7.3	21.2	3.90	S.W.	7.3
August....	49.8	71.5	11.0	11.4	22.4	4.32	W.	7.1
September.	67.5	73.3	9.9	10.8	20.7	3.28	W.	8.2
October...	65.0	70.1	11.4	9.7	21.1	4.25	W.	8.8
November.	77.0	70.5	10.4	8.7	19.1	5.20	N.W.	10.1
December.	78.0	72.7	11.3	7.3	18.6	3.57	W.	9.9
Spring	104.5	66.1	35.7	23.0	58.7	12.46	N.W.	10.0
Summer ..	57.0	69.7	36.8	26.4	63.2	11.85	W.	7.4
Autumn...	103.5	71.3	31.7	29.2	60.9	12.73	W.	9.0
Winter	82.5	71.4	30.4	24.4	54.8	11.12	N.W.	10.1
Year.......	114.5	69.6	134.6	103.0	237.6	48.16	W.	9.1

* Miles per hour.

BOTZEN, BOZEN, or **BOLZANO,** is a town of Austria in the South Tyrol, fifty-two miles south of Innsbruck, and thirty-two miles northeast of Trient. It is reached by the Brenner Railway, and has a population of over nine thousand. Botzen is beautifully situated at the confluence of the Talfer and Eisach rivers, 900 feet above the level of the sea. Though a very healthful locality, and often visited for the grape-cure, it is held, by some authorities, not to be a suitable resort for the sick, on account of the constant winds and rapid changes of temperature. The surrounding mountains are too far off to protect the town from the cold north and east winds that sweep through the openings of the valleys of the Eisach and Talfer, and from the northerly current that sometimes comes from Meran. At other times a sirocco blows from the valley of the Adige, into which the Eisach empties two miles below the town, and in summer the heat is extreme. Besides these disadvantages the city has few open and sunny residences, and the exhalations of the narrow, close streets and court-yards, are very disagreeable to visitors, who find few pleasant walks or places of assembly (Eulenburg, "Real Encyclopädie"). The temperature is generally warmer than at Meran. Hann ("Handbuch der Klimatologie") gives the following averages: January, 33° F.; April, 55° F.; July, 74° F.; October, 55° F.; and yearly average, 54° F. The average temperature in 1856–58 was: October, 52.5° F.; November, 39.5° F.; December, 33.2° F.; January, 30.4° F.; February, 33.6° F.; March, 44.8° F.; April, 55.8° F. (Eulenburg, *loc. cit.*). *William G. Le Boutillier.*

BOURNEMOUTH, in Hampshire, on the south coast of England, five miles from Christchurch, is accessible by a branch of the Southwestern Railway from Ringwood. It first attracted attention as a mild climatic health resort about 1840, and has grown rapidly in favor on account of

its sheltered position and equable temperature. It has now several good hotels, a library, reading- and assembly-rooms, baths, and other accompaniments of a fashionable sea-side resort. In 1871 the population was 5,906.

The town is prettily situated on rather steep sandhills richly wooded with pine, enclosing a bay open to the southwest wind but protected from northwest, north, and northeast winds. In spring the cold east and northeast winds are disagreeable, although some protection is afforded by the easterly cliff and by the trees. Of all the winter health-resorts on the south coast, Bournemouth alone resembles Arcachon in the pine-trees, although their resinous exhalation is here less strong. Many residences are quite surrounded by pine-trees, but the forest is becoming thinned by the encroachment of the houses.

The subsoil is sandy and carries off the rain so rapidly that open-air exercise is permissible directly after a shower. According to the observations of Drs. Falls and Compton, the annual rainfall is 30 inches, and there are 120 to 160 rainy days per year. The average humidity of the atmosphere ranges from 75 to 86.

The even temperature resembles that of Torquay. In 1862–72 the average maximum by day in July was 71.9° F., and the minimum at night in January, 35.6° F. In winter the cold is not excessive. In the unusual December of 1878, Bournemouth had the next highest temperature to Ventnor, 22° F.

As a winter health-resort, Bournemouth has been found best adapted to consumptives. The sanatorium for diseases of the chest gives fairly satisfactory results, although patients as a rule do not stay long enough. They should remain six or eight months, to obtain the most beneficial local and constitutional effects.

Williams, father and son, in their consumptive cases, noted improvement in sixty-five per cent., no change in ten per cent., and in twenty-five per cent. deterioration. Weber (Ziemssen's "Allgemein. Therap.") reports satisfactory results in most cases of chronic catarrh and inflammation and in the early stages of phthisis; while residence at Bournemouth was not well borne in cases of asthma with a tendency to neuralgia and in various anæmic conditions. *W. G. Le Boutillier.*

BOW-LEGS. Syn.: Genu Varum; Fr., *Genou en dehors;* Ger., *Gekrümmte Beine.* A deformity characterized by an outward curve of the long bones of the lower extremity, usually associated with a relaxed condition of the external lateral ligaments of the knee-joint. One or both limbs may be affected in varying degree, or genu varum of one side may coexist with genu valgum of the other. A forward curve of the tibia is sometimes met with in conjunction with the lateral deviation, or it may exist alone and constitute the sole deformity. The most common predisposing cause of bow-legs is rachitis, but the deformity may arise in other conditions characterized by a softening of the bones, or relaxation of the external knee ligaments. It is most frequently met with in early childhood, but may be developed late in life, as a result of osteomalacia or osteitis deformans (local osteo-malacia of Paget). A senile form of curvature is sometimes seen. Gravity is not the sole exciting cause of this condition, for the deformity may occur through muscular action, before any attempts at walking have been made. The anterior curve of the tibia, in its commencement at least, is to be referred to the action of the strong muscles of the calf of the leg.

A spontaneous cure of bow-legs very frequently occurs. This is difficult of explanation, but is probably due to a more rapid growth of bone upon the concave side, after the rachitic process has subsided. It cannot be referred to an elastic recoil of the curved bones, as has been alleged. The anterior curve of the tibia never, or very seldom, undergoes this spontaneous straightening. The treatment of bow-legs varies according to the condition of softness of the bones. In rachitic curvatures, previous to the stage of eburnation, simple lateral supports will usually suffice to correct the deformity. These consist in a light steel upright on either side of the limb, fastened to the sole of the shoe below, and jointed at the knee and ankle. The uprights terminate in a thigh-band encircling the limb, one or two inches below the perineum. A second band, to steady the uprights and to keep them in apposition to the limb, encircles the calf just below the flexure of the knee. Two or three straps may be attached to the inner upright, opposite the point of greatest curvature, passing over a shield of hard rubber, or of thin, well-padded steel, between the limb and the outer upright. These will serve to exert a constant slight force against the apex of the curve. When the bones are soft, manual pressure, regularly employed for a few minutes several times a day, is often sufficient to straighten the bones; or the leg may be lightly bandaged to a well-padded splint, applied to the inner side of the limb every night. The child should never be allowed to walk about during the day, without some simple support. When the bones have once become hardened, these simple means will not usually suffice, and a resort must be had to operative measures. Several methods of straightening the limbs have been proposed, only two of which have hitherto proved of value. Each of these has the same object in view, viz., to break the bones and reset them in a straight position. In one, this result is obtained by a simple fracture, without solution of continuity of the soft parts—osteoclasis; in the other, an incision is made down to the bone, and the latter is severed by a chisel and mallet—osteotomy. The former of these methods is the safer in any but the most skilful hands, and is equally effective in securing the desired result. For a description of these operations, see under their respective headings. Constitutional treatment is not often called for, but in certain cases in which the rachitic processes are active the appropriate remedies for this condition may be necessary. *Thomas L. Stedman.*

BOX (*Buis*, Codex Med., root, bark, and leaf). The common garden Box is *Buxus sempervirens* Linn.; Order, *Euphorbiaceæ* (*Buxeæ*); or, according to many botanists, it is the type of a distinct order, "*Buxaceæ.*" It is a slow-growing evergreen shrub, rather variable in habit, but usually compact, with a very short trunk, and numerous leafy branches. The leaves are opposite, two or three centimetres long, elliptical or oval. They are dark-green and shining above, pale beneath, thick and leathery. The flowers are clustered, monœcious, small, and greenish-yellow; the fertile usually terminal, with six sepals and a three-celled, six-ovuled, ovary. Staminate flowers lateral, more numerous, with four sepals and four stamens. Fruit a loculicidal capsule. The bark of the younger twigs is green, that of the old trunks gray and tuberculated.

Box is a native of the southern part of Europe and the East. It is frequently cultivated for ornament there, and has been a favorite bordering-plant for flower-gardens in the United States, where it grows fairly, but very slowly. It seldom blossoms in New England. All parts of the plant are bitter; the leaves and twigs are the most available for medicinal use. By far the most important product of this valuable shrub is its wood, which for many purposes is unequalled. It is very heavy, intensely hard, light and pleasant in color, very fine and uniform in texture, and capable of receiving a beautiful and durable finish. It is the best of all woods for draughtsman's scales and wood-engraving, but is unfortunately becoming scarce and expensive.

The bitterness of Box is due to the alkaloid *buxine*, discovered by Fauré in 1830. It is a white, amorphous powder of a persistent bitter taste. It is very insoluble in water ($\frac{1}{5000}$), but dissolves pretty easily in alcohol, and more freely in chloroform. A second alkaloid, *parabuxin*, was found by Pavia to accompany the buxine in Box; and it is still probable that some other principle may be found, to explain the poisonous qualities it has been occasionally observed to have.

Uses.—Box has had some reputation as a febrifuge and tonic; in large doses it is purgative and emetic. It is suspected of being sometimes used to replace hops in beer; but is little employed in medicine to-day. The alkaloid *Buxine* (Bebeerine), either from Box or Bibiru, has been offered as a substitute for quinine in intermittents, but is much inferior; in the same large doses, it deranges the

stomach and digestion; in small doses it, however, is an excellent tonic. The *Sulphate* and *Hydrochlorate* are in the market. Dose, as a tonic, from five to ten centigrammes (0.05–0.10 = gr. j. ad ij.); as a febrifuge, eight or ten times as much (0.5–1 = gr. viij. ad xvj.).

ALLIED PLANTS.—There are about twenty species of *Buxus*, mostly Asiatic. They do not have much affinity with the rest of the order *Euphorbiaceæ*. (See CASTOR-OIL.)

ALLIED DRUGS.—*Buxine* has been found in several plants of entirely different orders, and is probably, like berberine, a rather extensively distributed alkaloid. The bebeerine of Bibiru (*Nectandra Rhodiæi* Schomb.), the Pelosine of Pareira (*Chondodendron tomentosum* R. et P.), as well as of the False Pareira, have been shown by Flückiger and others to be identical with this alkaloid, although it is not quite certain that the physiological effects of buxine from all these sources are the same. Of the above drugs, Bibiru may be fairly compared with Box; Pareira is used empirically for effects that are not due to the buxine it contains. The Berberine series (see BARBERRY, etc.); the Dogwoods, Quassia, and other neutral bitters (see GENTIAN); and the Cinchona alkaloids (see CINCHONA), are, like Buxine, bitter tonics, and much more used for the purpose. *W. P. Bolles.*

BRAIN, ABSCESS OF. ETIOLOGY.—In the large proportion of cases, abscess of the brain is probably the result of injury to the head. In very many instances the injury gives rise to a compound fracture of the skull, but sometimes the cerebral lesion in question supervenes in simple fracture of the skull. Abscess arises more frequently when a splinter of bone has been detached from the inner table and driven into the substance of the brain, but it also develops at times when the bones of the skull are merely fissured. In a not inconsiderable number of cases, indeed, the cerebral abscess has followed an injury which has resulted merely in a superficial wound of the scalp, and has been attended, at the time of the accident, with very slight or no cerebral symptoms. This circumstance should be borne in mind in the consideration of so-called idiopathic cerebral abscess. Perhaps not a few such cases may be explained by an injury which gave rise to such slight symptoms, at the time of its occurrence, that the latter had entirely escaped the memory of the patient.

In the majority of cases of abscess due to injury the encephalitis is found in the vicinity of the injured part of the skull, but in exceptional instances it is found on the opposite side of the brain.

Next in importance to traumatism as an etiological factor stands caries of the petrous portion of the temporal bone, which is attended usually with suppurative otitis media. The primary lesion is generally present from early childhood, as a sequel of scrofula or one of the infectious diseases common to that period. Not infrequently the mastoid cells are also implicated in the carious process. The cerebral abscess due to such conditions may arise in various ways. Sometimes the upper surface of the bone is gradually eroded and inflammation sets in in the dura mater and pia mater, causing these structures to become matted together, and adherent both to the bone and to the cortex of the brain. The inflammation and suppuration of the brain tissue then follow from the direct propagation of the inflammatory process. In such an event it is common to find purulent meningitis also present; this condition may be confined to the base of the brain or it may also spread to the convexity. In another series of cases the inflammation of the bone gives rise to external pachymeningitis of that portion of the dura mater which is in contact with the diseased bone, and also to phlebitis and thrombosis of the lateral sinus. In a third series of cases, finally, the caries is found to be confined to the interior of the bone, the venous sinuses and the membranes of the brain being unaffected.

Toynbee claimed that disease of the external auditory meatus is associated with abscess of the cerebellum; of the tympanum, with abscess of the cerebral hemispheres; of the labyrinth, with abscess of the medulla oblongata. All that can be said in this respect with any degree of certainty is that caries of the anterior part of the petrous portion is apt to lead to abscess of the cerebral hemispheres (usually the parietal lobe), and caries of the posterior part to abscess of the cerebellum.

Gull and Sutton state that nearly one-fourth of all cases of cerebral abscess is due to disease of the ear, and von Troeltsch puts the proportion even as high as one-half.

In rare cases, abscesses of the brain are caused by an extension of inflammation from carious or suppurative processes in the orbital cavity, the antrum of Highmore, or the nasal cavity, either from the passage of pus through some of the foramina at the base of the skull, or from caries of the bones in this region.

In quite a considerable proportion of cases, cerebral abscess has been observed in connection with pulmonary diseases of various kinds, such as empyema, fetid bronchitis, bronchiectasis, phthisis, pulmonary gangrene, acute pneumonia.

Naether states that in the Leipzig Clinic, 8 abscesses of the brain were observed in connection with 49 cases of gangrene of the lung, 37 cases of fetid bronchitis, and 12 cases of bronchiectasis—*i.e.*, in nearly eight per cent. of all the cases. It must be remembered, however, that the apparent causal relation may be due, in some cases, to mere coincidence, in view of the great frequency of pulmonary diseases as a cause of death. But that this etiological relation between cerebral abscess and pulmonary disease does exist, cannot be doubted. Boettcher has reported a case of cerebral abscess secondary to a pulmonary abscess, and was able to detect pulmonary pigment in the pus contained in the cerebral abscess. In such cases the pus contained in the abscess usually has a fetid odor.

In cases of this kind, as well as in those associated with caries of the petrous portion of the temporal bone, but in which the carious process has not extended to the inner surface of the bone and has not involved the dura mater or pia mater, the secondary abscess in the brain is presumably the result of infection through the agency of the blood-vessels or lymphatics.

In rare cases insolation acts as a cause. Bernhardt reports a case of abscess of the parietal lobe evidently due to this cause, and in which a fatal termination ensued very rapidly.

Like all other organs of the body, the brain also is the seat of metastatic abscesses in pyæmia. Such abscesses are usually multiple and small in size. They are generally unsuspected during life, for the reason that the general constitutional symptoms are so severe that any superadded cerebral phenomena are regarded merely as manifestations of the blood-poisoning.

These remarks also hold good concerning the cerebral abscesses observed in the course of ulcerative endocarditis.

The category of so-called idiopathic abscesses of the brain is being continually narrowed. A considerable proportion of such cases date from a period when post-mortem examinations were not made with the care devoted to them at the present time, and therefore the primary source of the disease could very readily be overlooked. Although the existence of such a class of cases cannot be absolutely denied, still no case should be pronounced idiopathic until careful search has been made without success in all the organs for some possible source of suppuration. Even then, as we have stated above, it must be remembered that a long-forgotten injury may have been the starting-point of the disease.

PATHOLOGICAL ANATOMY.—Abscesses of the brain vary extremely in size. Some of the multiple abscesses occurring in the course of pyæmia or ulcerative endocarditis may be the size of a pea. Old chronic abscesses may occupy a large part of a cerebral hemisphere, or, perhaps, a considerable portion of the cerebellum.

Acute abscesses contain a thin pus, usually of a color varying from yellow to green, sometimes of a darker shade, from admixture with blood. Under the microscope this is found to contain pus-corpuscles, drops of myeline, granular matter, and detritus of the nerve-elements. The walls of

the abscess are usually irregular and jagged, and tear readily from the contact of the fingers. The cavity is irregular in shape at first, but at a later period it tends to become more rounded. For a varying distance around the cavity the brain substance may have a reddish speckled appearance from enlargement of the blood-vessels and the presence of capillary hæmorrhages. Still more externally the brain-tissue is stained slightly yellow and softened from inflammatory œdema. The latter phenomenon is observed sometimes over a large area, and often appears to be the immediate cause of death. Sometimes the abscess ruptures into one of the lateral ventricles, and, in rare cases, the pus makes its way through the foramen of Monro into the opposite ventricle. In such cases death almost always occurs before ependymitis supervenes. In other cases the abscess ruptures through the cortex (almost always at the convexity), and in this event, likewise, death may supervene before the development of meningeal inflammation. But in a large number of such cases meningitis occurs at the site of rupture and rapidly spreads over the entire meninges. Quite a number of cases have been reported in which the pus made its way through the original site of injury to the skull, through the external auditory meatus, through the ethmoid bones into the nasal cavity, or through the orbital plate into the orbit.

Chronic abscesses are usually round or ovoid in shape, and are provided generally with a connective-tissue membrane of variable thickness which lines the cavity. Rudolph Meyer states that about seven weeks usually elapse before the formation of a well-defined membrane. The contents of the cavity are usually somewhat viscid, and consist of broken-down pus-globules, drops of fat, cholesterine crystals, and granular matter. In a very few instances the contents have been found condensed into a thick, cheesy consistence, and in one case it is stated that earthy matter was present (calcification). When the abscess is of large size, fluctuation can usually be detected upon the convexity, the convolutions are flattened upon the side of the lesion, and sometimes the falx cerebri is pushed toward the opposite side of the brain.

When the abscess is situated in such a position (particularly the cerebellum) that the escape of fluid from the ventricles is interfered with, internal hydrocephalus may be the result.

Widespread œdema of the brain is found not infrequently in cases of cerebral abscess, even in those provided with a thick membrane, and which do not appear to have given rise to much pressure. General cerebral anæmia is also observed quite often under such circumstances. The development of these sequelæ is still unexplained.

Clinical History.—The symptoms of an acute abscess of the brain after injury vary to a remarkable extent. Perhaps the immediate symptoms of the traumatism have been very slight; the scalp has been wounded, but the bones have escaped injury, and the patient is not supposed to be seriously injured. Or the patient has presented for a few days the signs of cerebral concussion, and then apparently recovers. For a variable length of time (from a week to two or three months) he continues in apparently good health, but then begins to complain of headache, dulness, and irritability. The headache increases in severity, and the patient may be confined to bed on account of the general malaise. The irritability and excitement likewise increase, delirium supervenes, and epileptiform convulsions may make their appearance. The character of the pulse varies from time to time, and the temperature rises and runs an irregular course. Nancrede claims that the temperature in cerebral abscess is usually subnormal, but this is not corroborated by our own experience. The pupils present no special changes.

Then the delirium changes into hebetude, somnolence, and coma; the pulse becomes rapid and irregular. Death either ensues rapidly or recovery slowly occurs, and the patient is restored apparently to health, with the exception, perhaps, of a monoplegia or hemiplegia, or even without any local symptoms. He then enters upon the so-called latent stage. The symptoms described are very like those of acute meningitis, and, indeed, this lesion may be associated with the encephalitis from the beginning, or it may develop secondarily.

Sometimes the symptoms begin with great suddenness, and at once assume an alarming aspect.

In another series of cases the symptoms of concussion or compression of the brain, due to the original injury, continue without intermission or improvement, and are rapidly merged into those due to the developing encephalitis and abscess formation, so that it is impossible to tell when the one process ends and the other begins. Such cases usually run a more rapid course than the former variety.

Finally, not a few cases have been reported in which the abscess has remained entirely latent for a long period, without giving the least indication of its presence. In fact, the autopsy alone may reveal the existence of a hitherto unsuspected chronic abscess. In a case observed by Nauwerk, the period of latency lasted twenty-eight years.

Sometimes the sole symptom of the so-called latent stage has been the occurrence of epileptiform convulsions, so that the case has been regarded as one of ordinary epilepsy. In other cases, chills, followed by a hot stage and sweating, occur at irregular, or, in rare cases, perfectly regular intervals, so that a diagnosis of intermittent fever has been made. An instance of this kind has come under our own observation. Usually, however, such patients also suffer from violent headache, frequently localized in the vicinity of the abscess.

Abscesses of the frontal lobe are more apt than others to be unattended with symptoms during the stage of latency. In a case of this kind, observed by me in the person of a lunatic, the mental condition seemed to be somewhat improved during the period of latency (one month). The night before her death, she had what were supposed to be hysterical convulsions (irregular twisting movements without loss of consciousness), as the patient had exhibited other hysterical symptoms for a year (the injury which gave rise to the abscess was received a month before the onset of the convulsive seizures). On the following morning the patient was found dead in bed. The autopsy showed an abscess of the frontal lobe, which had burst (evidently shortly before death) through the convexity.

It is unnecessary to say that, if the abscess is situated in such a position that it either involves the cortex in some part which presides over a special function, or destroys the white matter in such a manner as to cut across the fibres leading to such portions of the cortex as we have referred to, the corresponding symptoms will be produced. Thus, hemiopia, aphasia, word-deafness, paralysis of individual nerves (very rarely), monoplegia, or hemiplegia may be produced in this manner. As occurs likewise in the clinical history of tumors of the brain, hemiplegia results usually from a succession of monoplegias, due evidently to a gradual spread of the destructive process from one set of fibres to another. This fact may often be of invaluable service in making a regional diagnosis.

But, unlike tumors of the brain, cerebral abscesses rarely give rise to paralysis of cerebral nerves, or to the development of choked disk. The former peculiar feature is due to the fact that abscesses are so commonly situated in the substance of the hemispheres, and, moreover, have a decided tendency to spread to the surface of the convexity, not toward the base.

The absence of choked disk may be accounted for, perhaps, by the fact that the encephalitis spreads by causing adjacent parts of the brain to become directly involved in the inflammatory process, and in this way less pressure is produced upon adjacent parts. The non-occurrence of choked disk in abscesses of the cerebellum, which are so often associated with internal hydrocephalus, remains unexplained.

In a considerable proportion of cases, however, all "head symptoms" are entirely wanting during the so-called latent stage, and we are sometimes astounded at the autopsy at discovering the great apparent disproportion between the amount of brain-tissue destroyed and

the slight character of the symptoms which had been produced. This is especially striking if we compare the symptoms with those which usually result from cerebral hæmorrhages, even when much smaller in size. It must be remembered, however, that the latter lesion is usually situated in such a position (internal capsule and surrounding parts) that comparatively slight destruction of tissue interferes materially with the conduction of nervous impulses.

Vomiting is a not infrequent symptom, and may occur when the stomach is either full or empty.

In certain rare cases, the sole symptoms observed during the period of latency are those of mental derangement, and the patient is supposed to suffer merely from insanity as the result of injury to the head. In a case recently under our observation, such an error in diagnosis was made by a very eminent neurologist, and the true nature of the case was only revealed at the autopsy, as the psychical symptoms persisted, uncomplicated with any other manifestations, until the terminal meningitis set in.

As a general thing, the latent period is brought to a close by a sudden irruption of symptoms, beginning either with an epileptiform convulsion, or a series of convulsions, with great exacerbation of the headache, mental irritability and delirium, or with sudden coma. The symptoms which follow are very similar in character to those which we have described above as occurring in acute abscess. After a short period (varying usually from a few hours to several days), the symptoms either terminate fatally (this is the rule) or they gradually clear up. But sooner or later, after another period of latency, in which the symptoms are more violent than in the first period, a second outburst occurs, which terminates fatally.

From the reports of a few isolated cases it seems probable that chronic abscesses may undergo spontaneous recovery, inasmuch as the pus becomes cheesy or even calcareous. But such an event, if it happens at all, must be extremely rare.

Diagnosis.—The development of cerebral abscess should always be suspected if grave symptoms, like those we have described in the preceding section, make their appearance after the primary symptoms of concussion or compression have subsided, and it has been supposed that the patient has recovered. The occurrence of an initial chill must be regarded as a particularly important symptom. Although a chill is not observed very often in the beginning of a cerebral abscess, it is not a part phenomenon of any other disease of the brain for which abscess could be mistaken under such circumstances. Vomiting is also an important sign, and is a much more frequent symptom than the chill.

The diagnosis of the situation of an acute abscess (except in cases of compound fracture of the skull, in which the dura mater or the brain itself has been laid bare and the existence of an abscess is rendered probable by contusion of the brain-tissue or the absence of pulsation) is rarely possible unless a circumscribed paralysis has been produced. In such an event the regional diagnosis must be made according to the principles laid down in the articles on Diagnosis of Brain Lesions and on Cerebral Localization (both in the present volume). It must be remembered that in the disease under consideration the "indirect" symptoms (due to pressure and inflammatory œdema of the surrounding parts) are especially prominent from the very nature of the lesion, and regional diagnosis, therefore, is correspondingly less positive and exact. Even a bilateral meningitis (for which, as we have stated above, the disease is liable to be mistaken) may be attended exclusively with unilateral symptoms. In a case of this kind under our observation, in which unilateral convulsions occurred, followed later by hemiplegia of the same side, the autopsy showed that less exudation was present upon the convexity of the opposite side of the brain than upon that of the same side as the paralysis.

As a general thing, however, we must rely mainly upon the presence of localized symptoms in order to distinguish abscess from meningitis. The latter disease may also be excluded with considerable certainty, if the brain-symptoms develop later than a week or ten days after the original injury.

If disease of the middle ear is the primary source of infection, we must differentiate the secondary cerebral manifestations from those due to thrombosis of the lateral or cavernous sinus. The latter condition sometimes gives rise to puffiness and œdema of the skin over the mastoid process, and of the eyelid, and to prominence of the eyeball. If the patient does not succumb rapidly, evidences of secondary pyæmic processes in other organs of the body are manifested. As we have stated in the section on pathological anatomy, thrombosis and abscess due to caries of the temporal bone are apt to be associated with one another.

The diagnosis of chronic cerebral abscess is also extremely difficult. It is very liable to be mistaken for tumor of the brain. The history of a previous injury to the head is extremely important, since tumors develop very infrequently as the result of traumatism. We should also inquire very carefully into the existence of any other known causes of abscess, such as disease of the middle ear, of parts adjacent to the skull, etc. Another important differential diagnostic point is the absence, in cerebral abscess, of choked disk—a symptom which, as is well known, is very frequent in tumor of the brain. Neuro-retinitis has been observed in a few cases of abscess, but this change appears in so many diseases that it possesses very little importance in differential diagnosis.

The occurrence of chills without any other ascertainable cause is also significant. Although usually irregular, they appear sometimes with such regularity as to give rise to the suspicion of intermittent fever.

Prognosis.—The prognosis of this affection is extremely grave, indeed almost hopeless in the large majority of cases. Spontaneous recovery by thickening and caseation or calcification of the contents of the abscess, or by rupture externally through some preformed opening in the skull (caries of the temporal bone, ethmoid bone, or open wounds of the skull with destruction of bone), is exceedingly rare, and in practice can never be looked forward to as a probable outcome. Even when the pus succeeds in making its exit, the abscess usually refills, and proceeds to a fatal termination.

In chronic abscesses the fatal event may be delayed for one or two years, or even a much longer period.

Statistics seem to show that operative interference is attended with good results in a certain number of selected cases.

Treatment.—Medical treatment of this affection, apart from meeting the individual symptoms as they arise, is utterly useless, as we possess no remedy which will cause the absorption of the pus after it has once formed.

Prophylactic measures are useful, perhaps, in preventing encephalitis after injuries to the head. The chief measures are absolute mental and bodily rest (the patient kept on his back, not allowed to sit up, to read, or to talk with those around him), which should be continued, if the injury has been violent enough to produce unconsciousness, for at least a week or two after the subsidence of the cerebral symptoms. In addition, the bowels should be kept thoroughly open by some mild saline, or by small doses of calomel.

In a certain proportion of cases surgical interference by trephining and evacuation of the pus is justifiable, particularly in chronic abscesses, or those associated with compound fracture of the skull. But this should only be done when the symptoms are of such a nature as to warrant us in making a regional diagnosis. In the present state of our science this applies only to the ascending, occipital, and temporo-sphenoidal and third left frontal convolutions, *i.e.*, in so far as surgical interference is warranted.

In our opinion, the indiscriminate probing of the brain-tissue in search of an abscess is entirely unjustifiable.

Leopold Putzel.

BRAIN, ANÆMIA OF. Anæmia is a condition and not a disease in the proper sense of the term. Moreover, it is a condition which rarely or never exists uncompli-

cated. The causes which produce it are very apt to produce independently irritation and inflammation, or the same conditions which at first bring about an anæmia of the brain may, if their action be longer continued, excite in its place a cerebral hyperæmia. In the present state of our knowledge it is, moreover, often impossible for us to prove whether certain symptoms are really produced by an anæmia or a hyperæmia of the brain, and in such cases we are forced to come to a decision on very imperfect grounds.

Of the fact that the anæmia in itself acts as an irritant on the nerve-centres there can be no doubt, but its chief effect on them is produced through the deprivation of nutrition which it causes. In considering anæmia of the brain, it is not possible for us to differentiate the symptoms caused by deprivation of nutrition to the cerebral tissues through loss of blood and those caused by deprivation of nutrition to the same parts on account of the poverty of the blood in nutritive material suited to their needs. Hence, the term cerebral anæmia has come to denote not only that condition in which there is an absolute diminution of the amount of blood in the brain, but also all those, so long as no toxic element is involved, in which the blood supplied to the brain is, from its composition, incapable of affording due and sufficient nourishment to the tissues. As a change in the condition of the blood is in most cases concurrent with a diminution in its amount, we may fairly say that cerebral anæmia, when universal, is usually "a complex condition, depending not merely upon a deficiency of the quantity of blood supplied to the brain, but also upon a change in its quality, and upon a diminution in the intracranial pressure" (Ross, ii., 611).

Anæmia of the brain may be either universal or partial, according as the whole or a portion only of the organ is involved. Partial anæmia, except when caused by occlusion of a blood-vessel through pressure, thrombosis, or embolism, is rare, and its symptoms are often not recognizable during life.

We shall hence consider here only universal cerebral anæmia. This may be either acute or chronic, and it may be due to a condition confined to the brain alone or may form part of a general anæmia.

Acute universal anæmia of the brain is always the result of the sudden withdrawal of a large quantity of blood from that organ. It occurs typically in ligature of the large arteries in the neck, the innominate, the carotids, or the vertebrals. These operations are performed usually either on account of injury, or for some tumor or aneurism. The vertebrals are sometimes tied as a cure for epilepsy.

1. The most common cause of acute cerebral anæmia is, however, undoubtedly hæmorrhage. This may occur from any part of the body, provided only that sufficient blood be lost with sufficient rapidity. Putting aside hæmorrhages due to injuries, the more common forms are metrorrhagia, especially post-partum, epistaxis, hæmoptysis, and hæmorrhages from the stomach and intestines; occasionally also the rupture of aneurisms.

In cases of hæmorrhage from injury the influence of shock must always be taken into account, as there are few cases of severe injury in which it does not exist to a greater or less degree. The pathological condition existent in shock is as yet unknown, though, perhaps, the most probable hypothesis is that maintained by Gröningen, that the complex of symptoms known by this name is due to an exhaustion of the medulla oblongata and of the spinal cord, produced by violent and severe drains upon their strength. Other writers consider shock as due to sudden changes in the calibre of the blood-vessels. Thus it is defined by Fischer as a reflex paralysis of the vaso-motor nerves, especially of the splanchnic, produced through a traumatic concussion. However this may be, cerebral anæmia is certainly produced by shock, and, as Travers says of shock and fainting: "They differ in degree and duration more than in kind."

2. Acute cerebral anæmia may also be produced by any sudden change in the distribution of the blood in the body at large. Any cause which suddenly attracts a large quantity of blood to one portion of the body will naturally reduce the amount which can go to the other parts, and hence, will induce an anæmia in them. This sudden change in the general distribution of blood in the body is said to occur after violent labor, when, the uterine vessels being suddenly released from pressure, large quantities of blood enter them freely and are thus withdrawn from the rest of the body. To this cause is probably in part also due the serious symptoms which sometimes occur after the withdrawal of large quantities of fluid from the pleural or peritoneal cavities. Another example of this form of disturbance is given in the action of Junod's boot, which, if carelessly used, may provoke dangerous symptoms.

3. A third cause of this form of anæmia is want of energy in the action of the heart. This is a common cause of chronic anæmia, but the acute form may readily be produced by any sudden demand for increased exertion on the already weakened heart. This is readily seen in anæmic persons and those suffering from insufficient action of the heart, in their liability to faint on any slight exertion, or even on rapid change of position. More especially is this the case in convalescents from acute febrile diseases, and it is particularly apt to occur after acute pneumonia. This frequently takes place when the patient rises suddenly from the horizontal position, the change in the distribution of the blood, which under normal circumstances would not be perceived, making itself felt.

In organic diseases of the heart cerebral anæmia in the acute form frequently occurs, more especially in aortic regurgitation, in which death from syncope is not uncommon. Persons suffering from myocarditis or from fatty degeneration of the heart are likewise peculiarly liable to attacks of fainting.

Anæmia of the brain may in like manner be produced by irritation of the vagus nerve through its action on the heart. Brown-Séquard, and others have found that crushing of the right semilunar ganglion causes stoppage of the heart, and the deaths which sometimes occur from syncope in nervous and delicate persons, who are suffering from hepatic colic, may, perhaps, be referred to some similar cause. We may also mention here, though without any special reference to the method of their causation, those cases of syncope and collapse which occur in perforation of the stomach or intestines, and in which death is not infrequent.

That intestinal disturbances even of a light character are especially liable to produce syncope, is well known. Even a transient abdominal pain or a slight attack of intestinal colic frequently causes the symptoms of faintness or even actual syncope. Syncopal cardialgia and a tendency to faint, are said to be especially common in those suffering from the dyspepsia of gout.

4. Again, a diminution of the amount of blood in the brain sufficient to produce the symptoms of cerebral anæmia, may be caused through the spasmodic contraction of the cerebral arteries. This is supposed to occur when, from emotion or mental excitement, there is pallor of the countenance, and even loss of consciousness, without any failure of the action of the heart. The not uncommon occurrence of fainting at the sight of surgical operations, or at the sight of blood, would come under this head. Syncope, and even sudden death, may be caused by the sudden advent of any strong emotion—surprise, terror, grief, or joy. How far shock or the irritation of the vagus comes into play in these cases is yet undecided.

In attacks of epilepsy it is extremely probable that we have likewise to deal with a spasmodic contraction of the cerebral blood-vessels, due to the irritation of a cerebral vaso-motor centre, but this cannot in the present state of our knowledge be considered as proved (Nothnagel).

From Nothnagel's experiments on the course of the vaso-motor nerves of the vessels of the pia, it seems probable that, at least at times, a portion run their course in company with the fibres of the cervical sympathetic, while another, and perhaps more important division, first make their appearance in the superior cervical ganglia, and "also, still above the ganglion, paths for them very probably exist in the cerebral nerves." If these views be

true, direct irritation of these parts must tend to produce anæmia of the brain.

That cerebral anæmia may also be excited by irritation or stimulation of the sensitive nerves is well known. Intense pain may produce faintness or even syncope, but the exact method of action by which this effect is brought about must still be considered undecided. Nothnagel's and Krauspe's experiments on the sciatic and crural nerves do not appear conclusive, more especially in the face of the conflicting results obtained by Riegel. Ross states that these symptoms "may result from reflex irritation of the vagus or direct irritation of the sympathetic. But the direct effect produced on the nerve-centres must also contribute to the result." Nothnagel considers the cerebral anæmia caused by catheterization to be likewise due to irritation of the vaso-motor centres.

5. Cerebral anæmia may in like manner be produced by the sudden introduction of foreign substances into the cavity of the cranium, thus inducing compression of the blood-vessels. The most common cause of this is an effusion of blood; but in cerebral or meningeal hæmorrhage the pathological condition is a complex one, and it does not properly come within the limits of this article.

6. It is probable that acute universal anæmia of the brain may be induced by certain poisons, but direct proof in this regard is still wanting.

Chronic universal anæmia of the brain may be produced not only by all the causes mentioned above, provided that their action be gradual and continued for a sufficient length of time, but also by all conditions of the system in which the amount of blood as a whole is much lessened or its active power much diminished. Hence, in all cases of general anæmia and chlorosis we find a corresponding anæmia of the brain. This is especially apt to occur after long and wasting diseases, such as phthisis pulmonum, Pott's disease, or long-continued suppuration in any form. More particularly is this the case whenever large quantities of fluid of any sort are steadily withdrawn from the body for any length of time, as in chronic diarrhœa. Hyperlactation is a not infrequent cause. Nothnagel, moreover, considers that many of the symptoms occurring in cases of starvation are directly referable to cerebral anæmia, although in these cases there probably always exists a greater or less amount of cerebral irritation.

Anæmia of the brain and meninges is specially apt to occur in the convalescent stage of acute febrile diseases, "the late cerebral anæmia of severe fevers" of Jaccoud, who considers, however, that this is not a simple anæmia but an anæmia with dyscrasia.

Affections of the heart, moreover, are not uncommon factors in the etiology of chronic anæmia. Whenever there exists a weakness of the cardiac action, whether due to functional causes or to organic lesions, we may suspect anæmia of the brain. This is probably always present to a greater or less extent in all cases of fatty degeneration of the cardiac walls and in most cases of uncompensated valvular disease. It is most frequent in insufficiency of the aortic valve.

How far chronic anæmia may be brought about by the presence of extraneous substances in the cranial cavity is an open question. The presence of inflammatory exudations, transudations, or tumors is supposed to at times cause an anæmia by pressure, but in many cases an irritative process seems to preponderate and a hyperæmia exists.

Partial or circumscribed anæmia of the brain is caused by the diminution of the calibre of the blood-vessels supplying a portion of the brain, or by their occlusion. Unilateral anæmia is produced by ligature of the carotid. In many cases it is but temporary, and the symptoms soon disappear, but in others they remain and become more or less permanent. This depends, at least in part, on the condition of the communicating arteries of the circle of Willis, irregularities in which were found by Ehrmann in from nineteen to twenty per cent. of the bodies taken at random and examined by him.

The commonest cause of partial anæmia in the brain is thrombosis, or embolism, by which a blood-vessel is partially or wholly occluded. The presence of tumors or exudations may likewise cause a partial anæmia by pressure exerted over a vascular area, or on a special blood-vessel. How far local spasm of the cerebral blood-vessels may cause circumscribed anæmia is still doubtful. Nothnagel states that it may occur in hemicrania and in the petit mal (epilepsy). Eulenburg says, "The group of symptoms called hemicrania sympathico-tonica is to be explained by supposing a unilateral tonic spasm of the vessels of the head caused by tetanus in the cervical region of the sympathetic, or in the spinal centre of the cervical sympathetic."

Symptomatology.—Experiments made on compression of the carotids in healthy male adults show that the following effects are produced. In the first place, there is pallor of the countenance, then convulsive efforts to close the eyes are seen, with contraction, to be followed later by dilatation of the pupils, a sighing respiration, dizziness, staggering, and finally unconsciousness. A sensation of choking may occur, and sometimes vomiting and general convulsions. How far these symptoms may depend on the anæmia pure and simple, and how far they may be due to other causes, we cannot consider here. In the present condition of our knowledge it is not possible to determine with absolute certainty, in regard to many of the symptoms which are present in conjunction with anæmia, as to whether they are due to the anæmia itself or to various concomitant conditions; while on the other hand there are many conditions in which the symptoms generally ascribed to anæmia are present, and in which the condition and circumstances of the general body would point most strongly to an anæmia of the brain, and yet in which, on post-mortem examination, the actual state of the cerebrum would seem to be rather hyperæmic than anæmic. Thus Flemming, in the "Pathologie und Therapie der Psychosen," says: "The fluctuations in the quantitative relations of nutrition in the brain vary between the extremes of lack and of excess of blood, anæmia and hyperæmia. Under circumstances which, as well from the precedent injuries as from the whole behavior of the organism, would lead us to conclude, in so disproportionate a blood-supply (oligæmia), that even the brain could not readily be provided with its normal needs, we still see the psychical functions altered in a manner which points far more to an increased supply of blood. The autopsy also, in such cases, shows the opposite of what we should expect from the general oligæmic condition of the body. It shows the brain throughout, or partially, on its surface, or in its internal portions, reddened by the blood seen through the tissues, while the cut surface is dotted with numerous bloody points and the vessels are distended with blood. In short, there where we expected anæmia it shows far more a hyperæmic condition."

Hence, in describing the symptoms which are usually referred to anæmia of the brain, we desire that these facts be constantly borne in mind, that in many cases symptoms have been ascribed to anæmia which were in all probability due to other conditions of the brain, and even when the anæmia coexists there is in a large proportion of cases no proof that the symptoms are due to it alone.

In acute anæmia of the brain we have a series of symptoms extending all the way from general weakness to profound insensibility, and which are known according to their intensity by the names *eclysis*, *lipothymia*, and *syncope*. All these are apt to be classed together under the name of fainting-fit. These symptoms are subjectively usually as follows: A person about to faint usually notices first a slight oppression in the breathing, and a sensation of lightness in the head. He is often inclined to gape, and finds difficulty in fixing or concentrating his attention. Gradually the respiration becomes deeper and more labored, and a feeling of nausea and weight in the epigastrium comes on. At the same time his face becomes paler and paler, and he becomes more and more dizzy, until he finds it difficult to maintain his equilibrium. His head feels tense and his ears begin to ring, a mist comes over his eyes, and at times he is scarcely

able to see, though still able to stagger toward the fresh air. He is often nauseated, and perhaps vomits. Surrounding voices can be heard but not distinguished, and unless relieved, he becomes insensible, and falls without a cry to the ground. If now left to himself he generally soon recovers, but recovery can be readily hastened by the presence of fresh air, or by gentle stimulation of the olfactory nerves. Objectively, the principal symptoms noticeable are, in the first place, the extreme pallor of the face, especially marked on the mucous membrane of the lips, the gaping and deepened respiration, then the staggering or loss of control over the equilibrium. The pupils contract at first and then dilate, and the pulse becomes small and its tension is diminished. The skin is pale and cold, and a cold perspiration breaks out over the forehead and sometimes over the entire body. This stage ends in the abolition of consciousness and of voluntary movement.

These are the usual symptoms in a slight attack of fainting coming on gradually from exposure to heat and close air, or from mental emotion. Where the fainting, however, comes on rapidly, the prodromal symptoms may not appear, but the patient turns pale and falls insensible almost immediately. In severe cases, in addition to the previous symptoms, we may have generalized convulsions, sometimes extremely violent, and resembling in all respects epileptic convulsions. These are liable to occur in all cases of sudden and profuse hæmorrhage in previously strong and healthy individuals.

When the anæmic condition is produced more slowly, either from long-continued undernutrition of the body or as the result of a severe physical strain, as a serious fever or other acute illness, the symptoms present themselves in a somewhat different form. In children, after any severe strain on the physical forces, and particularly after intestinal diseases, in which a considerable amount of fluid is rapidly withdrawn from the tissues, we meet with the so-called *hydrencephaloid* disease, for our knowledge of which we are still principally indebted to its first describer, Marshall Hall, who "first gave a cursory sketch of this morbid affection in a little volume of 'Medical Essays' published in 1825." He there says: "The state of exhaustion is very apt to be induced in *early infancy*, and as the reaction is feeble at this period of life, the case soon assumes the character of sinking. This state of things is often mistaken for inflammation of the brain or hydrencephalus."

The symptoms of exhaustion in children are, in the earlier stages, a certain restlessness and irritability of temper, accompanied by a condition of abnormal sensitiveness of the nerves of sensation and of the special senses. The child cries on being touched, avoids the light, and starts at any loud noise. The sleep is restless and broken, and the child not infrequently moans, sighs, and screams. At the same time we have the signs of fever in the bodily heat, the flushing of the face, and the frequent pulse. If this condition be allowed to continue, the second stage of exhaustion is liable to set in—the stage of depression. In this the symptoms are just the opposite of those which have preceded. The child lies quiet in a somnolent or semi-comatose condition, interrupted, however, at times by convulsions, which are generally distributed over the body. The face and extremities are cold, pale, and blue. The eyes are fixed, and the pupils, which are at first contracted but afterward dilated, cannot be affected by light. Strabismus is not infrequent, and contraction of the muscles in the nape of the neck may also occur. The voice is often husky, and cough may be present. The respiration in this stage is slow, irregular, and sighing, and as death approaches there is rattling in the throat.

The differential diagnosis between this condition and that of hydrocephalus must be made largely from the history of the case. The most important symptom is the condition of the fontanelle, which in this disease is depressed, while in hydrocephalus it is usually tense. This is probably the apoplexia ex inanitione of the older writers. "It differs from syncope in coming on gradually and in continuing a considerable time, perhaps a day or two, and it is not, like syncope, induced by sudden and temporary causes, but by causes of gradual exhaustion going on for a considerable time. It differs from mere exhaustion in the complete abolition of sense and motion, while the pulse can be felt distinctly, and is, in some cases, of tolerable strength. I have seen in adults the same affection, though it is perhaps more uncommon than in children" (Abercrombie).

In adults as in children, chronic universal anæmia of the brain is liable to be characterized by a condition of abnormal stimulation, both mental and physical. In both there is the same restlessness, uneasy sleep, and intolerance of light and sound; while in adults the mental irritability is probably more prominent only because it is more readily shown. In the severer forms, and more particularly in cases of starvation, delirium, the "delirium of inanition," is liable to occur. This is usually active and frequently maniacal in character, and is accompanied by hallucinations, illusions of sight and hearing, and not infrequently by delusions of persecution. Nothnagel states that there is almost always an undertone of sadness, and that hence the symptoms as a whole belong to the type named melancholia agitans. It is said that occasionally this may pass into permanent insanity. In regard to the delirium of starvation, Longet writes as follows: "There is some consolation for us, after considering the pathological conditions in which hunger presents itself, with the character of inexorable irresistible force, in turning to the analogous phenomena which are produced in the healthy individual when deprived of food. We are compelled to believe that under these circumstances there supervenes a pathological state; a peculiar delirium, that of hunger, the delirium of starvation appears; were it not so, we should refuse to admit that the sentiment of egotism could reach the degree to which we see it carried in the starving man. Hunger speaks louder than laws, religion, feelings, all is hushed before its imperious commands."

In the case of Lieutenant Greely, who was exposed to slow starvation in the late Lady Franklin Bay Expedition, the following record was made by Dr. E. H. Green, June 22, 1884, the day of rescue: "On admission fainted after being carried below in the wardroom, and vomited. Nervous system: excitable and irritable, at times almost emotional, eyes wild and staring; insists on talking, craving news, and demanding food, complains of no pain." His bodily weight was then 120 pounds. In August, 1883, it had been 168 pounds. The next day, "No sleep, mind more tranquil but too active, great desire to talk and read; less persistent in demanding food; complains of soreness in limbs. June 25th, marked improvement, mind more tranquil; talks quietly without excitement; slept two or three hours naturally, awoke refreshed." After this there was steady improvement. The details in regard to the other organs of the body are purposely omitted, as not being relevant to our subject, but there was no organic lesion anywhere. All the symptoms here present were probably due to lack of food.

We must here again emphasize the fact, that in these cases it is impossible in the present state of our knowledge to decide how far these symptoms are actually due to a condition of cerebral anæmia, or whether, as some observers think, there is present a fluxional hyperæmia of the brain.

Some of the symptoms present in cerebral anæmia deserve special consideration, and among these we should place first the disturbances of the organs of special sense. Tinnitus aurium is one of the commonest symptoms of cerebral anæmia, even in its lighter forms, and is usually accompanied or followed by partial deafness. It is probable that these symptoms are due, at least in part, to irritation of the auditory nerve, for although the blunting of the mental perception might readily be adduced as the cause of deafness it could hardly be held to produce a ringing in the ears. Abercrombie's oft-quoted case of a much-weakened and anæmic patient, who was deaf when he sat upright but could hear well when he lay down, or when his face was reddened, would tend to confirm this view. In the same way the appearance of specks before the eyes and the blurring and dimness of vision which so frequently occur may be referred to

irritation of the optic nerve. The occasional occurrence of total amaurosis would also seem to point to this. It is most common after severe hæmorrhage, especially from the stomach, rarer in connection with inanition. It may or may not be accompanied by severe pain in the head. It may come on suddenly in the course of a few hours or it may take several days to develop. Travers says: "It succeeds somewhat abruptly to uterine flowing and large and sudden depletion for acute diseases. The pain is not confined to the region of the orbit, though it affects chiefly, if not exclusively, the same side of the head; it is that peculiar nervous pain to which women are subject after uterine hæmorrhage, attended with a sense of defined pressure, as of an iron finger on the brain, and sometimes a distressing, jarring noise, like that of a mill or threshing-floor, or the rattling of the shingles as a heavy wave of the sea recedes." Samelsohn found cause in one case to suspect hæmorrhage into the sheath of the optic nerve. A. v. Graefe in his cases found nothing on immediate examination, but afterward atrophy of the optic papilla. Schweigger (Transl., Philadelphia, 1878) declares that the relation between loss of blood and disease of the optic nerve is wholly unexplained and that the latter cannot be due to simple anæmia.

Disorders in the sphere of the motor nerves may be either convulsive or paralytic. Kussmaul and Tenner have shown conclusively that in rabbits convulsions are almost uniformly produced in cases of rapid, profuse hæmorrhage, or where the great arterial trunks leading to the brain are ligatured, except in the case of very weak animals or in such as were under the influence of ether. They found, however, that closure of all four of the arteries, both carotids and both vertebrals, was necessary in order to produce rapid convulsions. In all their cases the convulsions were epileptic in character.

In man convulsions have been noticed in connection with fainting from the earliest times. Hippocrates says in his Aphorisms: "Σπασμὸι γίνονται ἢ ὑπὸ πληρώσιος ἢ κενώσιος" (convulsions arise either from plethora or from anæmia). Marshall Hall, in his observations on blood-letting, declares that "convulsion is, after syncope, the most familiar of the immediate effects of loss of blood. It is most apt to occur in children and in cases of slow and excessive detraction of blood." . . . And again, "It is most apt to occur in cases in which the patient has been freely bled in a more or less recumbent position, in which the blood has flowed slowly, or in which time has been lost during the operation."

Anæmic convulsions rarely occur except after hæmorrhage, when the amount of blood lost must be considerable. The loss must occur all at once, or nearly so, and the patient must not have been previously in a much debilitated condition. Thus, children in a hydrocephaloid state, and persons suffering from chronic anæmia, are not likely to be attacked with anæmic convulsions.

In contradistinction to convulsions *complete* paralysis without coma does not occur in universal cerebral anæmia, though after ligature of a carotid temporary hemiparesis and paralysis are not uncommon. If the paralysis be permanent there is probably some organic lesion present.

The general weakness of the limbs in syncope may be regarded as a form of paresis.

The pathological action of a diminution in the supply of blood to the brain may probably be comprised under the following conditions: Diminution of the intracranial pressure, want of stimulus or nutritive material sufficient to maintain the normal cerebral action, and possibly a change in the composition or character of the blood.

The DIAGNOSIS of anæmia of the brain, except in those cases of partial anæmia due to the obliteration of blood-vessels, which do not come under consideration here, can only be made through consideration of the accompanying general symptoms. Inasmuch as in hyperæmia of the brain the local symptoms are in many cases the same as in anæmia, the differentiation of these two opposite conditions will depend much on the history of the case. Even the condition of the vessels of the face and head is no positive proof of the condition of the internal vessels, nor would an increase or diminution in the supply of blood in the retina afford a presumption that the same condition existed in the meninges. The condition of the heart and the influence of posture and of alcoholic stimulants afford further aid in determining the diagnosis.

The PROGNOSIS in common cases of syncope is decidedly favorable, although even in ordinary cases of fainting from mental influences fatal results now and then occur. Less favorable is it in cases due to severe hæmorrhage, even when not complicated by shock. On the other hand, in those cases of acute syncope where we have reason to suspect some weakness or lesion of the heart, for example, in all cases of cardiac disease, and in convalescence after acute febrile diseases, the prognosis is more serious. This especially applies to those cases in which the immediate cause of the syncope is some sudden change of position. In cases of chronic anæmia in the adult, syncope, as a rule, is not in itself a very serious symptom, but whenever a prolonged coma occurs, especially if accompanied by convulsions, there is cause for anxiety. In the hydrencephaloid condition in children, if the patient be seen and the disease recognized in time, recovery is probable under judicious treatment. The prognosis must in all cases depend, in this as in other diseases, in great part upon the severity of the symptoms. The condition of the pupils is said to form an important element in the prognosis, contraction always preceding dilatation, while they become normal again as the patient approaches recovery.

TREATMENT.—In simple syncope from mental emotion or from reflex irritation but little treatment is needed, except that the patient should be placed in a horizontal position and should be allowed plenty of fresh air, when recovery generally occurs quickly. Stimulants, such as ammonia, applied to the mucous membrane of the nose and air-passages, are of assistance. As the syncope becomes more severe, we employ cutaneous stimulants, the simplest and best of which is the sprinkling of cold water over the face and chest. Mustard may be applied to the skin, especially over the cardiac region; but the most effective external stimulant is the electric brush. Internal cardiac stimulants, such as coffee, alcohol, or ether are often of decided benefit. The carbonic dioxide in champagne is said to promote the rapid absorption of the alcohol, and hence this form should, when convenient, be used. In the severer cases, where the unconsciousness becomes prolonged, especially in those in which the loss of blood has been very great, the limbs should be bandaged, so as to drive all the blood as far as possible into the body and head. As a last resort, transfusion should be attempted.

In cases of chronic anæmia all means should be used to improve the general condition and strengthen the bodily forces. Milk is often the best form of nutriment, but where it can be borne a generous diet, including eggs and meat, is advisable. Wine is frequently of benefit, when given in suitable doses, and in severe cases it is often indispensable. Alcohol is generally of much importance in cases of hydrencephaloid, and in these Nothnagel recommends the early use of musk. In all cases the surface of the body should be kept warm, if necessary, by the direct application of heat.

Where mental excitement exists, all cutaneous stimulants or irritants are to be avoided, as they are said to increase the pain and restlessness. Under these conditions opiates often act well, better probably than chloral, which has also been recommended by good authorities.

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William N. Bullard.

BRAIN (ANATOMY). The article on the Macroscopic and Microscopic Anatomy of the Brain will appear in the Appendix. The delay will permit the preparation of a larger number of original figures from new dissections, and the incorporation of some results of observations now making upon the structure of the organ and the methods of its preservation, and also, it is to be hoped, warrant the introduction of a simpler nomenclature than that now commonly employed. *Burt G. Wilder.*

BRAIN AND NERVES, CHEMISTRY OF. The increased consistence of the brain, etc., shortly after death, is owing, probably, to the separation of certain previously dissolved bodies, such as cerebrin and cholesterin.

Attempts have been made to ascertain the composition of the gray and the white matter individually, but this is, of course, attended with almost insurmountable difficulties; so that all statements based upon such attempts must be considered as mere approximations to the truth. The specific gravity of the gray matter is 1.02927 to 1.03854; that of the white, 1.03902 to 1.04334. The reaction of the gray matter is during life always acid, that of the white neutral or alkaline, owing, it is suggested, to the fact that the ganglionic cells contain lactic acid.

The Chemical Constituents of the Brain and Nerves.—Water, albuminous matters, elastic-like substances, peculiar bodies containing phosphorus, cerebrins, neurokeratin, xanthin bodies (Scherer, Städeler in oxen); uric acid (very little in the ox, W. Müller); kreatinin, leucin, the lactic acid of fermentation, and volatile fatty acids (Müller); inosit, cholesterin, phosphates of the alkalis and of calcium; alkaline sulphates, sodium chloride, magnesia, iron oxide, silicic acid and fluorine in traces, lecithin, protagon, and nuclein (v. Jaksch); but lecithin may be a decomposition product of protagon.

With regard to the cerebrins (cerebrin, homocerebrin, and the encephalin of Parcus), it is not yet a matter of certainty whether they are themselves directly present in the brain or whether they first arise from the decomposition of protagon and such like complicated bodies.

Peculiar Constituents of the Brain and Nerves.—1. *Phosphorus-containing Substances.*—Protagon was separated by O. Liebreich, in 1864. Later, Diaconow and Hoppe-Seyler concluded from their investigations that protagon was not a simple substance but a mixture of two, lecithin and cerebrin. Comparatively recently, Gamgee and Blankenhorn confirmed, as they think, Liebreich's view.

Protagon may be obtained in microscopic needles and in an amorphous form. It is soluble in warm alcohol and ether; in water it swells but does not dissolve, except with the greatest difficulty. It forms a clear solution with glacial acetic acid. It is decomposed by a temperature of less than 100° C.; melts at 200° C. to a brown syrup. When boiled with baryta water it gives neurin, fatty acids, and glycerin-phosphoric acid, and, according to Diaconow, cerebrin.

2. *Substances Free from Phosphorus.*—*Cerebrin* was first obtained by W. Müller. Later Parcus concluded from his researches that the cerebrin of Müller could be separated into three well-characterized bodies: cerebrin, homocerebrin, and encephalin.

Cerebrin may be obtained in fine leaflets, but is not easily separated quite pure; also in a snow-white powder, soluble in boiling alcohol, hot acetin, chloroform, benzol, glacial acetic acid, but not in ether. At 170° C. it swells to a brown fluid. The phrenosin of Thudichum is an impure form of cerebrin.

Homocerebrin and Encephalin.—Homocerebrin may be obtained from raw cerebrin by repeated crystallizations from alcohol and ether. It occurs in very fine needles. In solubility it resembles cerebrin, but is more soluble in alcohol. It constitutes about a fourth of the raw cerebrin.

Thudichum's kerasin is an impure homocerebrin.

Encephalin occurs in very small quantities; crystallizes in leaflets. Boiled with water, unlike homocerebrin, it forms a paste.

Neurokeratin was first prepared by Aug. Ewald and Kühne. It is a very hard powder of a light yellow color; insoluble in cold sulphuric acid and in caustic potash. When boiled with dilute sulphuric acid it gives more tyrosin and less leucin than albumin does. It contains 2.93 per cent. of sulphur.

The following table of Petrowski gives the result of the analysis of the brain-matter of the ox, which does not appreciably differ, so far as is known, from the brain of man in its general chemistry:

Constituents.	Gray substance.	White substance.
	Per cent.	Per cent.
Water	81.60	68.35
Solid remnant	18.40	31.65
Albuminous matters and glutin	55.37	24.73
Lecithin	17.24	9.90
Cholesterin and fats	18.68	51.91
Cerebrin	0.53	9.55
Matters insoluble in water-free ether	6.71	3.34
Salts	1.45	0.57

When brain matter is reduced to an ash, it is observed to have an acid reaction, the greater part of the phosphorus of the lecithin being represented by phosphoric acid.

Geoghegan, first removing the lecithin and then ashing the brain-substance of man, found in 100 grains the following properties:

SO_4K_2	0.411
KCl	2.524
K_2HPO_4	0.266
$Ca_3P_2O_8$	0.013
$MgHPO_4$	0.084
Na_2HPO_4	1.752
Na_2CO_3	1.148
Excess CO_3	0.082
FeP_2O_8	0.010
	6.290

T. Wesley Mills.

BRAIN: ANEURISM OF CEREBRAL ARTERIES. Aneurisms of the cerebral vessels (independently of the miliary aneurisms which are treated of in the discussion of cerebral hæmorrhage) are comparatively rare, though Coats makes the surprising statement that, "in persons under forty years of age cerebral hæmorrhage is due to the rupture of aneurisms in the great majority of cases."

These aneurisms are situated commonly on the arteries of the circle of Willis, and, according to Lebert, the vessels are affected in the following order of frequency: Basilar, middle cerebral, internal carotid, and posterior communicating, and the artery of the corpus callosum. The other vessels are only exceptionally the site of this lesion. Robertson reports a case in which an aneurism had burst into the right lateral ventricle. It was situated on a branch of the right middle cerebral artery, and had hollowed out a bed for itself in the substance of the corpus striatum and optic thalamus.

According to the majority of writers, the vessels of the left side appear to be affected more frequently than those of the right side, but in Coats' eleven cases all were situated on the vessels of the right side of the brain. The male sex seems to furnish a much larger proportion of the cases than the female sex.

The anatomical structure of cerebral aneurisms is entirely similar to that of similar lesions in other vessels of the body, and therefore need not be discussed here. They vary from the size of a pea to that of a hen's egg, though tumors of the latter dimensions are extremely

rare. As a rule, they do not exceed the size of a hazelnut (*vide* Plate III., Figs. 4 and 5).

The immediate causes of the origin of this lesion have not been ascertained very clearly, but there appears to be little doubt that it does not bear such close relations to atheromatous degeneration as aneurismal dilatation of other vessels of the body. A number of writers believe that the cerebral aneurisms are sometimes the result of embolism, associated with endocarditis, the assumption being that the presence of the embolus causes increased pressure upon the walls of the vessel, and thus leads to dilatation. According to Ponfick, the aneurism is the result of weakening of the vessel from the pushing of the embolus against it.

The lesion has also been attributed to the effects of injury to the head.

The aneurism produces various local effects. When situated in the circle of Willis it may cause erosion of the bones at the base of the skull. As a matter of course, it also produces pressure on adjacent soft parts, and as the circle of Willis is usually involved, the various cerebral nerves are mainly subject to compression, then the medulla oblongata, pons Varolii, and crura cerebri. Klippel reports a case in which an aneurism of the right posterior communicating artery, as large as a walnut, had compressed the adjacent brain-substance from the edge of the pons to the right optic nerve. During life the patient had suffered from ptosis of the right side and complete immobility of the right eye, with disturbance of vision on both sides.

The aneurismal sac may also press upon adjacent vessels and give rise to thrombosis, with its usual train of sequences. In other words, the pressure-effects are very similar to those of other forms of tumor situated at the base of the brain.

When the aneurism is situated upon the basilar artery it is apt to give rise to hemiplegia. According to Lebert, this occurred nine times in thirty-one cases. Schmidt reports a case in which a diagnosis of cerebral hæmorrhage had been made:

A man, aged fifty-seven, had an apoplectic attack with unconsciousness, left hemiplegia, including the facial nerve; the pupils were sensitive to light; sensibility was intact. The condition of the lower limb improved considerably, the arm became contractured. Death occurred two years later from pneumonia.

The autopsy disclosed a cylindrical aneurism of the basilar artery, extending from the lower end of the pyramids on the left to the corpora candicantia on the right. There was a depression of the pyramids in the medulla oblongata, and its edges were softened; also a depression in the pons, chiefly on the right side. There was distinct gray degeneration of the left lateral column of the cord and median bundles of the right anterior column.

Although, as we have stated above, the symptoms of cerebral aneurism are usually very similar to those of other kinds of tumors situated at the base of the brain, it differs from them in the fact that choked disk is a very rare symptom in the history of the former affection. In this respect it is similar to cerebral abscess, and, like the latter, it may also remain latent until the occurrence of a sudden apoplectiform attack, due to the rupture of the vessel. In quite a number of instances it has been found that the first rupture of the vessel did not prove fatal, and that a second rupture occurred after a variable period, sometimes extending over a couple of years.

The majority of writers assert that the rupture of the aneurism gives rise to meningeal hæmorrhage, but this opinion should be revised in view of the fact that in all (eleven) of Coats' cases, and in a number reported by other observers, the hæmorrhage took place into the substance of the brain. The extravasation is generally so extensive that it breaks through the brain-tissue into the lateral ventricles, and often also into the other ventricles.

Treatment of this affection is altogether futile. The most that can be done is to relieve the pain (which is often even more excruciating than that caused by other forms of cerebral tumor) by the administration of morphine.

Leopold Putzel.

BRAIN, ATROPHY OF THE. As applied to the brain, the term atrophy embraces the results of three different kinds of morbid processes. In the first two there is really atrophy in the ordinary meaning of the term—that is, loss of substance through previously existing disease. Thus: First, loss of substance, either from idiopathic disease inherent in the brain, progressive general paralysis; or associated with general disease, infectious fevers; or, from failure of nutrition, senescence, insanity. Second, loss of substance from destruction of tissue, or from a sclerosis secondary to localized destructive lesions. In the third class there is no proof that a tissue once existing has been destroyed, and the term atrophy can only be used by a certain license. But for practical convenience there are many reasons for ranking the cases in question with the atrophies. They are, third, cases of imperfect development of the brain, cerebral agenesia, partial or general (microcephalus).

This classification of cerebral atrophies is traversed by another division into congenital and acquired; since many cases of arrested development of the brain are clearly traceable to diseases identical with those which occur after birth. The agenesia is then secondary, and, except from its intra-uterine origin, could be referred to the second class of cases.

Congenital, primary, and general atrophy of the brain constitutes microcephalus, the rarest form of idiocy (Ireland). No destructive lesion is discernible, but the size of the brain as a whole is much below normal, and the internal proportion of its parts is disturbed. The dimensions of the cranium correspond to those of the brain, and thus during life the size of the latter can be estimated by measurements of the former. Normal mental faculties are impossible with an adult head of from eleven to thirteen inches in circumference and from eight to nine inches from the root of the nose to the posterior border of the occipital bone. A circumference of fourteen to seventeen inches and an antero-posterior diameter of eleven to twelve inches implies a brain too small for ordinary intelligence (Voisin). Ireland calls microcephalic all adult heads below seventeen inches in circumference.

The lightest human brain on record is six ounces, in a child five months old (Sanders). In this the circumference of the head was less than six inches. Several brains are described of seven ounces (normal weight for men, forty to fifty-two and one-half ounces; for women, thirty-five to thirty-seven and one-half ounces). In microcephalic brains, the frontal lobes taper to a point; the occipital lobes either taper, or are much shortened, in either case exposing more or less of the cerebellum. The parietal and temporo-sphenoidal lobes are the best developed. The corpus callosum is often thinned, or shortened at its posterior end. The island of Reil may be left uncovered. The convolutions are remarkably simple; few secondary folds are developed. The disposition of many sulci is changed, the fissure of Sylvius shaped like a **V**, instead of a **Y** (Vogt); the calcarine fissure is prolonged so as to separate the gyrus fornicatus from the gyrus hippocampi (Putnam-Jacobi), the bridging convolutions of the occipital lobe indistinct or wanting (Betz). In a celebrated hypothesis, microcephalic brains have been considered to constitute anatomic reversion to the ape type (Vogt). There is, however, no constant resemblance between the two; the brain of the microcephale may be simpler than that of orang or chimpanzee, it is not similar (Gratiolet, Adriani).

The intelligence of microcephalic individuals who survive is rudimentary, but at various degrees removed from imbecility, complete aphasic idiocy. There is no definite proportion between the degree of intelligence and the size of the brain. In those who attain adult age a certain amount of speech is often possible, and there is some power of attention, memory, and emotionality. Sometimes the amount of intelligence is remarkable, if we consider the dimensions of the cranium (case, Antonia Grandoni; circumference of head at age of forty-one, thirteen inches). There is usually full and restless use of the limbs, and the impressions of the senses are lively. The

absence of local or general paresis distinguishes cases of pure microcephalus from those in which the arrest of cerebral development is associated with destructive lesions. Sometimes, however, the muscles are notably feeble, the characteristic restlessness of microcephaly is exchanged for immobility, varied by rhythmic, swaying motions (Meynhert). In these cases there is probably nutritive alteration of the brain-tissue; or deficient elaboration of its minute structure (Jastrowitz). There may be persistence of the molecular substance which precedes the formation of the medullary sheaths to the nerve-fibres, or of the large granular fat-cells, which belong to the transitional stage, and have been sometimes taken as evidence of congenital inflammation (Virchow).

Congenital Primary (?) and Partial Atrophy.—In this class of cases, one or more portions of the encephalic masses are absent, and no traces remain of destructive lesions sufficient to account for their disappearance. Thus they have been explained by a primary aberration of development. The explanation is most plausible in regard to partial or total defect of the corpus callosum (Hitzig). This great commissure begins to develop toward the end of the fourth month of pregnancy, by buds which appear on the internal lateral surfaces of the hemispheres, and grows simultaneously inward and backward. In partial defect it is the posterior portion of the corpus which is wanting, showing an arrest of the partly completed process. The arrest sometimes involves the fornix trigonum and septum lucidum, sometimes these are intact. In all recorded cases, the anterior white commissure is preserved. The lateral ventricles are distended. This fact suggests that an undeveloped corpus has been destroyed by a ventricular effusion, the latter subsequently reabsorbed. The cerebellum has several times been found defective. In one celebrated case, unique, according to Hitzig (?), the organ was completely wanting, being reduced to two small knobs, at the base of a serous cyst which occupied its place under the tentorium (Cruveilhier and Combetta, case Labrosse). Hitzig explains this case by an arrest of development; the author, much more plausibly, by a serous apoplexy which had occurred in early or in fœtal life. The loss of the cerebellum was accompanied by total absence of the pons; the pyramids arising directly from the cerebral peduncles. In Otto's case, the cerebellum was very much reduced in size by filling up of the occipital fossæ, through inflammatory thickening of the bones. The atrophy was therefore again a secondary lesion. Atrophy of the cerebral hemispheres is usually evidently traceable to destructive lesions. Sometimes, however, the traces of these have disappeared, and the atrophy then seems primitive. Cruveilhier describes the reduction of one hemisphere to one-third the size of the other. The space beneath the dura mater was filled with serous fluid. Isolated groups of convolutions are often atrophied: thus, lower part of the central convolution, with supra-marginal and superior temporo-sphenoidal (Beach); central convolutions on one side (*Virchow's Archiv*, July, 1882); central convolutions on both hemispheres (McNutt); right ascending parietal convolution (Bastian); right cerebrum, right crus, pons, and pyramid, left lateral pyramidal tracts (Pick); paracentral lobule, superior extremity of left ascending parietal convolution (Varigny). In many of these cases a primitive arrest of development has been assumed; in none is it demonstrated, or even probable (Steffen, Brouardel, Hasse). The entire class of cases should therefore be consolidated with secondary atrophies.

Congenital Secondary Atrophy.—This is partial or general, according either to the extent of the destructive lesion, or of the interference with the general development of the brain which may have been exerted by a localized lesion. Nutritive processes throughout the brain may be so disturbed that nerve-tissues cease to grow, nutrition is diverted to the cranial bones, premature ossification of the skull occurs, with some degree of microcephalus.

On the other hand, with a fœtal hydrocephalus, all the brain above the medulla may be destroyed and converted into a serous cyst, while the cranial bones continue to grow, until after birth the head attains a circumference of two feet (Cruveilhier).

The lesions leading to congenital cerebral atrophy are produced during fœtal life, and do not differ essentially from those which may be occasioned during the process of parturition, or so soon after birth that the symptomatology becomes identical with that of strictly congenital lesions. They are, in addition to the hydrocephalic effusions just mentioned, hæmorrhage, inflammation, and softening by steatosis.

Throughout fœtal life the rapidly growing brain is exposed to a graded series of accidents, corresponding to varying tendencies to effusions from the cerebral blood-vessels; now serous, now sanguinolent. At a certain degree of intensity these dropsies or hæmorrhages result in complete malformation of the brain (hydencephalon, or anencephalon); more limited in extent, the effusion results in the formation of a cyst, whose contents may be clear serum, or serum stained with the coloring-matter of blood. The cyst replaces whatever nerve-tissue has been destroyed. Intra-uterine cerebral hæmorrhage is much more liable to occur into the meninges than into the substance of the brain itself. A clot is then formed in the cavity of the arachnoid, and lying upon one or both cerebral hemispheres, which it is destined to compress during the process of its shrinkage. The subjacent tissues atrophy under the double influence of the pressure and of the sclerosis excited by its irritation.

Precisely such arachnoid hæmorrhage, with consecutive atrophy, is a not uncommon accident of a difficult parturition; and is thus the efficient cause of many cases of idiocy and spastic contracture. Hæmorrhage is also possible, but much less frequent, during the first months or year after birth. The cerebral atrophy, however, can only be called congenital when dating from accidents which occur previous to all distinct psychic development, thus hardly after the first month.

Meningo-encephalitis is, during the period immediately succeeding birth, more frequent than hæmorrhage, and also occurs before birth. An intense form, occurring at the third or fourth month of pregnancy, is probably the cause of the pseudencephalic monstrosity. Traces of a more tolerable, and even extensive, grade of inflammation, are found in thickened brain membranes, enclosing shrunken masses of nerve-tissue, or even empty of these. All but the most limited and localized cases of meningitis are liable to be complicated by hæmorrhage from the tender blood-vessels. Localized basal meningitis may interfere with the development of the brain, and thus, if the paradox be permitted, cause a species of primary atrophy, with premature ossification of the skull. The most striking effect of such lesion, from its proximity to the optic chiasma, is a descending neuritis and atrophy of the optic nerves.

When a portion of the brain has been destroyed by either hæmorrhage or inflammation, serum is poured out to fill the threatened vacuum. This non-encysted fluid is found both in the ventricles, in the cavity of the arachnoid, and in the subarachnoid space. It constitutes the so-called hydrocephalus *evacuo*, which must always be interpreted as a secondary lesion, and not as the essential cause of the symptoms observed during life.

In certain cases a portion of the nerve-tissue of the brain is found to have simply disappeared, sometimes throughout the entire depth of the hemisphere, thus leaving an opening which leads from the convexity pia to one of the ventricles (porencephalic defect, Kundrat). This lesion is not entirely peculiar to the new-born, for it has been found in adults after chronic brain disease (Cotard). In the new-born, however, it is due to a peculiar lesion, a steatosis of the nerve-substance, which results in red or white softening, according as it is or is not complicated by vascular congestion and capillary hæmorrhage (Parrot). The foci of steatosis contain a great number of granular corpuscles, due to the fatty infiltration of neuroglia-cells; also free granulations and species of cylinders, resulting from deformation of the corpuscles of

Gluge. The veins are occluded by thrombi. The nerve-tissue is reduced to a milky pulp, and, if the process lasts long enough, is gradually reabsorbed. The lesion may be circumscribed to a mass the size of a filbert, or may extend nearly throughout a hemisphere. In the first case it is usually multiple; in the second, the corpus callosum is the most affected.

One of the most important anatomical consequences of any of the above described lesions of the brain, is a degeneration of the motor tracts which lead from the seat of the lesion to the lateral and innermost fasciculus of the anterior columns of the spinal cord (crossed and pyramidal tract). This degeneration involves two elements: atrophy of the myeline sheaths of the nerve-tubes, and proliferation of the neuroglia-tissue between them. These elements are combined in various proportions, and when the atrophic process predominates, it is difficult to say that a simple agenesia of the spinal cord has not complicated an arrest of development of the brain. The fibres of the pyramidal tracts assume their myeline sheaths much later than the other segments of the cord, beginning at the fifth month; but they should be completed at birth in the cord (Flechsig), though still incomplete in the cerebral peduncles (Parrot). Simple defect of these sheaths therefore, without sclerosis, might, at birth, or a little before it, result from a check to the developmental process, dating from some epoch of the sixth, seventh, or eighth month of intra-uterine life. A lesion occurring during the last month, at birth, or shortly afterward, can only determine atrophy of the myeline sheaths through propagation of a nutritive irritation, which is further revealed in a co-existing proliferation of neuroglia. This, therefore, serves to distinguish between a primary and a secondary atrophy of the brain, the latter, except in steatosis, always involving irritation. (See case McNutt.) This degeneration can be traced by a column of grayish color, contrasting with the normal white, in the cerebral peduncle, half of pons and pyramid, on the same side as the lesion; and in the cord, through the posterior portion of the lateral column on the opposite side (Türck). A similar but much narrower gray tract occupies the inner part of the anterior column on the same side as the cerebral lesion. When the primary lesion is bilateral, the second is so as well. Under the microscope, the proliferated connective-tissue is readily traced by its brilliant coloration with carmine. Descending degeneration may be observed after the steatosis of the brain; but much more rarely and less completely than at other ages or after other lesions; a fact which Parrot attributes to the incomplete development of the cerebral portion of the pyramidal tracts. The same condition should tend to avert sclerosis after any lesions which occur early in fœtal life. Conversely, in the cases in which the symptoms of "spastic paralysis" indicate an extensive amount of secondary sclerosis, we may date the primary lesion back to near the moment of parturition.

According to Charcot, no cerebral lesions occasion secondary degenerations unless they involve the fibres of the anterior two-thirds of the internal capsule. These contain the superior fibres of the pyramidal tract. Atrophic lesions of the cortex are followed by diminution in the size of the corpus striatum on the same side, and, what is more singular, of the thalamus as well. The hemisphere of the cerebellum opposite to the lesion shares in the atrophy. When the lesion is localized primitively in one side of the cerebellum, the upper motor tracts are unaffected, but the olivary body on the opposite side wastes. Atrophic lesions of the basal ganglia are similarly followed by atrophy of the tracts below them, while those above remain unaffected. Lesions in the white substance of the hemispheres occasion no primary atrophy, but what is due to direct loss of substance, and no secondary atrophy, unless they involve the fibres of the pyramidal tract (see *ut supra*).

Symptoms of Congenital Cerebral Atrophy.—These are of two kinds: 1, Visible lesions; 2, disturbance of functions.

1. Hemiatrophia facialis has been observed at birth, and then, plausibly, referred to a cerebral hemiagenesia (Emminghaus). No autopsies exist to confirm or annul this hypothesis. The hemiatrophia of the brain, if existing, could only be a coincidence of the lesion of the trigeminus, to which this singular affection is usually referred. The majority of reported cases are acquired after birth.

Unilateral, or even monoplegic atrophy of the limbs is, however, frequently in cerebral hemiatrophia associated with motor paralysis and different forms of rigidity of the same limbs. Of the three symptoms, the paralysis is alone congenital; the atrophy of a limb or a segment of a limb, as a hand, is associated with diminished size of Ferrier's cortical motor-centre for the part. It is questionable whether the cerebral atrophy is then the cause or the consequence of the peripheric lesion. Similar wasting of the cortical motor-centre has been seen in an individual in whom the leg had been amputated many years before death. The cerebral atrophy was there evidently secondary. Many cases of congenital loss of the segment of a limb are due to intra-uterine amputation through ligature by amniotic bands. The accident then essentially resembles that of extra-uterine life.

Atrophy, in congenitally paralyzed limbs, appears after a time to be much more extensive than that of acquired cerebral paralysis. This is because the diminution of size depends principally upon interference with development. There is not loss of substance once acquired, as in spinal paralysis, but the affected limb remains behind its fellow in growth. Structural defects of the eye and ear are not unusual; thus, coloboma of the iris, eyelids, or retina, deformities of the external ear. Associated with the latter, as coincidently developed from the superior branchial arch, may be malformations of the mouth, hare-lip, cleft palate, etc. It is difficult to say, however, in what proportion the probability of such defects is increased by the existence of a cerebral atrophy compatible with life. Cerebral malformations of non-viable subjects are usually associated with other malformations of the body.

2. Disturbance of function. There are three in the motor sphere: Paralysis, rigidity, and convulsion; and to these must be added defect of intelligence. The sensibility is obtuse but not specifically affected. The paralysis is rarely complete, and by no means always localized. A general paresis of all the muscles of the body is the most frequent and earliest form of motor disturbance, even in well-defined unilateral cerebral lesions. The infant is able to move all its limbs, but cannot grasp with the hands, stand on the feet, sit up, or even hold its head up. Often after one, two, three, or four years the child acquires a certain amount of power in this respect. The motor paresis tends gradually to disappear, as in animals upon whom lesions of the cortical motor centres have been inflicted. When this happens, the cerebral lesion in children may also be referred to the cortex, and the basal ganglia be presumed to be intact. It is not infrequent, even, that congenital cortical lesions which render children incurably idiotic, are unattended by any paralysis whatever.

The symptoms of rigidity are especially interesting. The muscles of a single limb, an arm, may be affected with transient attacks of rigidity, but they rarely assume the permanently rigid contractions seen as a late symptom in acquired hemiplegia. The most characteristic form is the spastic paraplegia of the lower extremities. This is by no means exclusively due to cerebral agenesia, for it exists without cerebral symptoms, as a symptom of primary cord disease. But, when it is congenital, associated with defective intelligence or disorders in the range of the cranial nerves, it may certainly be referred to atrophia cerebralis. Many entirely superfluous hypotheses have been made in regard to this disorder. There are two forms. In one the muscles of the lower limbs are permanently rigid, and principally the abductors of the thighs, the hamstring muscles, and the gastrocnemii. From retraction of the rigid muscles the thighs are abducted, the legs partly flexed on the thighs, the feet on the legs. In the other form the muscles are supple while the child is recumbent, but the attempt to stand or walk is immediately followed by spasm in the muscles

indicated, or only in the abductors, so that the limbs are approximated or even crossed.

The bilateral character of spastic paraplegia does not always imply a double lesion of the cerebrum, though this was demonstrated in one remarkable case (McNutt) and inferred in another (Hutchinson). The immediate antecedent of all the spastic symptoms observed is, as in the late rigidity of acquired hemiplegia, secondary sclerosis of the pyramidal tracts in the lateral columns of the cord. Ninety-one to ninety-seven per cent. of the fibres of these tracts are normally crossed, the remainder direct (Charcot). The probabilities are, therefore, that the sclerosis and rigidity remain limited to the side opposite the cerebral lesion. But in children bilateral spasm may occur, either because the relatively minute extent of sclerosis on the same side as the lesion in the direct pyramidal tract exercises a greater functional effect, or because the proportion of decussating fibres has varied, leaving a much larger number in the direct portion of the tract, or because there has been a second decussation of motor-fibres in the cord below the pyramids (Charcot).

When spastic symptoms have developed, paresis of the rigid limbs is liable to be masked by them.

The third motor symptom, convulsion, is irregular in the time and frequency of its occurrence, and variable in its intensity. Convulsions coming on within the first week or two after birth generally indicate that the cerebral lesion upon which the atrophy depends has been caused during parturition. In cerebral atrophy of intra-uterine origin convulsions are delayed for several months after birth. They often coincide with the first symptoms of rigidity in the limbs, or precede these a little, and seem, therefore, to mark the development of the irritative lesions of degeneration. Convulsions are never due directly to the atrophy itself, but only to the secondary lesions, as they descend through the pons and medulla. The convulsion may consist in a momentary stiffening of the body, followed by clonic agitation of one or more limbs, or it may be a complete epileptiform paroxysm. The slighter forms are often frequently repeated, sometimes even in a single day; the complete attacks occur at longer intervals, of weeks, or even months. The close approximation of severe convulsions is dangerous, and a not infrequent cause of death. The intelligence is invariably impaired when the atrophy affects either cerebral hemisphere, or both, and is often deficient even in atrophy of those portions of the encephalon whose share in mental processes is not well understood, as the corpus callosum or cerebellum. It is probable in these cases that the finer structure of the cerebral cortex is imperfectly elaborated, even when no gross lesion is visible.

The degree of mental defect varies from simple flightiness and moral obtuseness (cases of atrophy of the cerebellum) to complete idiocy, and all intermediate stages of imperfection of the intelligence are observed. The speech is sometimes disproportionately affected. There may be complete aphasia, yet the expression of the face and the actions indicate considerable intelligence. It is possible, then, as Gerhardt suggests, that the lesion is localized in the speech-centre. In other cases there is no true aphasia, or inability to frame verbal conceptions, but articulation is interfered with by spasms of the facial muscles, analogous to those excited in the limbs by the attempt to use them.

Complete idiocy can be recognized in babies of three or four months old, by the vacant expression of face, the inability of the child to recognize its mother or nurse, its inattention to all the usual objects of baby interest, the absence of the smiles and cooings of a healthy child. The slighter the degree of mental defect the later is its recognition possible, as it will only become apparent as the conditions of existence become complete.

The cranial nerves are often involved in either the primary lesions which have caused the atrophy, or in the lesions secondary to them. Optic neuritis with secondary nerve atrophy may occur independently of any conditions of increased intra-cranial pressure. It is then attributable to a descending cerebritis. Early blindness in an infant renders detection of mental defect difficult or impossible. With or without blindness, irritative lesions of the sixth or third nerve, may occasion strabismus or nystagmus. Coloboma of the iris, as well as congenital defects of other parts of the body, is not infrequently present.

Acquired Cerebral Atrophy.—This is always secondary, but may be general or partial.

General atrophy of the brain is found to a certain extent in all prolonged wasting diseases, especially phthisis. It is conspicuous in senile decay, but is not associated necessarily with any particular age. The brain is heaviest at thirty, but while some brains begin to degenerate at sixty, others resist decay at eighty or even older. The brain is always wasted in alcoholism, and also in chronic insanity, usually as a whole, sometimes more markedly in one hemisphere, or in certain lobes, especially the frontal. The most conspicuous general atrophy is seen in diffuse meningo-encephalitis (general paresis of the insane). The total weight of the brain may sink in this disease below one thousand grammes (minimum normal weight for man, 1,130 grms.) and abundant serum may accumulate in the sulci. The frontal lobes are the most shrunken; after them the central convolutions; the cerebellum is always intact (Hitzig).

In all cases of chronic insanity, and most markedly in those of general paresis, the ganglionic cells of the cortex degenerate, become filled with fatty and pigment granules, and lose their protoplasm, nucleus, and axis cylinders.

In general cerebral atrophy both hemispheres are found sunken, retreating from the cranial bones, and the convolutions are thin and small, separated by wide furrows. In these enlarged sulci, as also in the dilated lateral and third ventricles, a serous effusion replaces the brain-substance, as in congenital atrophy. The cortical cover of the ventricles may be so atrophied that the arachnoid and pia come in contact with the ependyma entirely, or in limited spaces, constituting an acquired porencephaly.

Generalized atrophy may also result from localized lesions of the cortex, whose ganglionic cells seem to have an influence on the general nutrition of the brain, analogous to that of the ganglionic cells of the cord on the peripheric nerves. Finally, mental inactivity predisposes the brain, as other unused organs, to atrophy. Thus probably is explained the frequency of premature senile atrophy among peasants and other uneducated people.

Partial atrophies occur at the seat of a destructive lesion, and also in regions functionally correlated with this. Of such lesions, hæmorrhage is relatively less prominent than in fœtal life: embolism and thrombosis from atheroma of blood-vessels are the most frequent. Both are attended by red or white softening, or even by true localized encephalitis; the brain cortex may be infiltrated with leucocytes following the track of blood-vessels, and evidently exuded from them; and also with the granular corpuscles of Gluge, resulting from fatty infiltration of neuroglia cells. To these processes are due the characteristic yellow patches so frequently found on the cortex of the brain, varying from an entirely insignificant size to the entire surface of a hemisphere, and sometimes penetrating its entire thickness (Cotard). Cysts and sclerosis may be found in adult life as in congenital agenesia, and the waste of nerve-tissue may result, in either case, in simple defect; but the yellow patches are peculiar to acquired atrophy. The cysts are surrounded by an ochre-colored zone, where the nerve-tissue has been stained by hæmorrhagic effusion. Localized meningitis, or the outward-bearing pressure of a ventricular effusion may also determine atrophies, either partial, or, in the latter case, symmetrical and generalized. Tumors of the brain necessarily determine atrophy of the nerve-tissue they replace; but on their periphery there is an irritative hypertrophy, due, however, to proliferation of the neuroglia cells (Adamkiewicz). A band of this same sclerosis surrounds the focus of any destructive brain lesion. In senile atrophy occurs the vacuolation of the brain, long known as "l'état criblé" (Durand-Fardel), due to the enlargement of the lymphatic spaces surrounding the

blood-vessels. This dilatation results from prolonged and intense hyperæmia. Hasse observes that in partial atrophy the primary destructive lesions affect all elements of the brain-substance; in secondary atrophy the nerve-elements alone. But in general diffuse atrophy, as from diffuse meningitis, an irritative process is first initiated in the neuroglia, and the nerve-elements gradually waste. A linear cicatrix never forms in the brain, whose tissues are incapable of retracting; but there is always a space to be filled by a liquid, or by débris, or by newly formed connective-tissue.

The symptoms of acquired cerebral atrophy are essentially the same as those of cerebral agenesia, but differently combined, and existing in different proportions. When the lesion occurs in adult life, it can cause no arrest of development in the limbs, such as is so common in agenesia. Partial paresis or paralysis may be produced when the lesion is situated in the motor tracts. But superficial patches of atrophy of the central convolutions may be found in persons who had completely recovered from the paralysis caused by the initial lesion. As in agenesia, the rigid contractions of paretic or paralyzed muscles develop together with the secondary degenerations; the "late rigidity" of hemiplegics is not the immediate consequence of the primitive lesion. This rigidity occupies by preference the superior extremity, and is often confined to that, even when the lower extremity is also paralyzed. It acts in the sense of flexion, so that the arm is drawn to the side, the forearm partially flexed, the two last phalanges of the fingers flexed, while, from atrophy of the interosseous muscles, the first phalanx is allowed to be extended. Hence results the "claw-hand" as characteristic of hemiplegia. Tremors, localized clonic cramps, and general epileptiform convulsions occur. The latter may precede the cerebral atrophy and indicate the progress of a localized meningitis, of which this atrophy is to be the result; or they may indicate the progress of a descending sclerosis toward the pons; or they may announce the termination of the whole morbid process. Convulsions are most frequent with lesions of the cerebellum, the cerebral cortex, and the ventricles; but these belong to the primary process, not to the atrophy itself. In the former case other symptoms coincide—febrile attacks, temporary strabismus, irregularities of the pupils, headache. In the latter any mental deficiency previously existing deepens, even to dementia, and as the end draws near the patient becomes comatose.

In the atrophy of general paresis, the loss of muscular power is an early and prominent symptom. There is no rigidity. The mental defects in acquired cerebral atrophy are even more varying in nature and degree than the motor symptoms. Sometimes for many years these may be absolutely nil; then, if the atrophy progresses, the mental powers become gradually impaired. Simple failure of the intelligence is usually proportioned to the extent of the lesion; qualitative alterations of special faculties bear a more or less definite relation to the seat of the lesion. The dissociations of the speech faculty are numerous, giving rise to aphasia, amnesia, agraphia, alalia, and their combinations. Failure in memory, as in all chronic cerebral disease, is one of the earliest mental defects; the moral sense, dependent on the ethical mechanisms, the most delicate of all (Griesinger), is blurred.

Localized atrophies have been of great service in investigating the problems of localization in cerebral functions.

Prognosis of cerebral atrophy depends upon the extent of lesion, and upon its stationary or progressive character. When only a limited amount of brain-tissue is destroyed, its function may be vicariously performed by another portion, and the loss thus repaired. This is impossible with extensive acquired lesions. In the famous cases of congenital atrophy of the cerebellum or corpus callosum, however, the functions of these parts must have been performed by other organs, for their defect could not be diagnosed during life.

A broad distinction exists between the prognosis of congenital and acquired atrophy, in that the former far more frequently coincides with an arrested morbid process, the latter with one that is either continuously progressive, or liable to removal after temporary arrest. The mental defects due to atrophy of any portion of the adult brain cannot be repaired; the utmost to be expected is their limitation; the probabilities are that they will, steadily or intermittently, increase. On the contrary, in a brain partially atrophied while still in process of development, a vigorous psychic education may often hope to develop faculties by exercise of the intact portions. The difficulty of doing so increases with any form of disturbance of the speech faculty. Congenital paresis tends spontaneously to diminish, and muscular power may be greatly increased by systematized gymnastics. The paresis of acquired atrophy, unlike the paralysis due to destructive lesions, tends to permanence or to increase; the latter case being the rule in the general paresis of the insane. Muscular rigidities, contractures, and the deformities of limbs caused by them, increase for a long time in congenital cases, first as a result of the extending spinal degeneration, then as a consequence of malposition and adaptative shortening. The latter cause may be greatly palliated by appropriate apparatus; and the prognosis in respect to deformity, and to the power of walking and other use of the limbs, is hopeful in direct proportion to the influence of malposition, and inversely to that of the lateral sclerosis. Corresponding to the lesser extent of the brain lesion, the deforming contractures of acquired atrophy are much more limited, and therefore of less importance; their degree of amenability to therapeutic palliation is about the same. General acquired atrophy is not followed by deformity, for all the muscles are equally affected. The duration of life is quite indefinite. Death is never the direct consequence of the atrophy, but results from asthenia due to the progressive impairment of brain nutrition; from œdema, as the walls of the blood-vessels become more altered; from convulsions, especially associated with extension of secondary irritation, or from renewal of the primary accidents (hæmorrhage, thrombosis, meningo-encephalitis, etc.).

Treatment is palliative, and in the directions implied in the remarks on prognosis. The primary morbid process, if still going on, must be treated by appropriate measures; and an important point of the diagnosis is the decision whether this primary process is or is not arrested. In congenital atrophy, the mental faculties must be awakened as far as possible by psychological education, which, to attain the end, must be both persevering and profound. The muscular paresis must be combated by gymnastic exercises, the deformities by apparatus able to gradually stretch retracted muscles, to support limbs in proper position, and by means of springs and artificial muscles to facilitate attempts at voluntary movements. The proposal to relieve the deformities due to rigidity of the adductor femoris muscles by circumcision—an operation intended to relieve a hypothetical genital irritation—is most irrational. If relief ever follow this operation, it can only be in cases of entirely different character, a purely functional spasm, possibly associated with masturbation, and having nothing to do with lateral sclerosis of the cord. The convulsions which are so common in congenital atrophy require the usual treatment. For the eye symptoms (blindness, strabismus, nystagmus) nothing can be done.

In acquired atrophy treatment mainly consists in averting conditions which are likely to revive the primary accidents, and in treating these as they arise. The earlier in life the cerebral lesion occurs the more the conditions approach those of congenital atrophy; and when the accidents date from the first years of childhood the practical treatment is identical for the two classes of cases. Conversely, as a patient approaches old age both the primary accidents and the atrophy are more liable to be progressive, and the rôle of the therapeutist becomes more purely passive. There can be no longer question of developing a brain, checked in its evolution, but only of shielding it from new injuries which would cause fresh deterioration of faculties; hence mental strain and excitement of all kinds are to be avoided. The key-note of the treatment is the necessity for repose for the nervous processes proper and

for the cerebral circulation. Regulation of the social medium is the principal factor for the first; of exercise and climate for the second. Apparatus for deformity is less needed and less tolerated than in children. The contractures principally affect the upper extremities, instead of, as in children, the lower; and it is much more difficult to facilitate the functions of the arms than of the legs by prothetic apparatus. Still, with ingenuity, this may sometimes be accomplished.

Diagnosis.—In congenital or early cases it is principally necessary to distinguish between primary and secondary cerebral atrophy, and between the latter and the various lesions upon which it depends, as hydrocephalus, hæmorrhage, meningo-encephalitis. Primary atrophy may be inferred from deficient or idiotic intelligence, without motor disturbances or lesions of the special senses, while hydrocephalus may be excluded from the size of the head. The extreme degrees of diffuse primary atrophy constitute microcephalic idiocy, and are recognizable usually from the minute proportions of the cranium. The diagnosis cannot, however, always be made, for, though rarely, large portions of the encephalon may be absent, without any more defect in the intelligence than is often observed without gross cerebral lesion at all. And, on the other hand, the destructive lesion causing a secondary localized atrophy may be so limited that the descending degeneration occasions no characteristic symptoms, yet the finer mechanisms of the brain may be so jarred that the evolution of the mind is permanently impaired. In any case in which the associating fibres or the superadded convolutions (Broadbent) are affected, while the motor fibres prolonged from the crus remain intact, imbecility with preservation of muscular function is possible. In secondary atrophy, if the primary morbid processes have been arrested before they have been discovered, or at birth, it is often difficult, in the latter case impossible, to distinguish between them. Congenital hydrocephalus is recognizable when the head is already enlarged at birth, and may be a cause of dystocia. When the head begins to enlarge within a few weeks after birth, it is probable that ventricular effusion has already begun before. The probability is greater if spina bifida coëxist. In such cases it is sometimes the symptoms of the effusion, sometimes those of the atrophy and spinal sclerosis that predominate. An extra-uterine cerebral hæmorrhage or attack of meningo-encephalitis is indicated by the usual signs; but these are liable to be masked in infancy by convulsions and fever, common to both, and also to so many other infantile disorders. Persistence of an inflammatory process may be indicated by irregular recurrence of fever, associated with pain, retraction of head, pupillary symptoms, and other characteristic signs of meningeal irritation. Still these may also be aroused by the irritative process of degeneration, especially when this reaches the motor tracts in the pons and medulla. It may be said that in secondary atrophy at any age, the diagnosis may be made by the coincidence of three symptoms: mental defect, muscular paresis, and muscular contracture; these coming on gradually or after a period of stormy cerebral accidents. The various other symptoms enumerated may or may not be present; among them lesions of the cranial nerves are of the same order as the rigidities of the limb-muscles, and, like them, may be referred to the descending sclerosis accompanying the atrophy. Convulsions and fever may be due to this or to persistence or revival of the primary process.

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Mary Putnam-Jacobi.

BRAIN: CEREBRAL HÆMORRHAGE. ETIOLOGY.—The most frequent cause of non-traumatic cerebral hæmorrhage is the occurrence of miliary aneurisms in the vessels of the brain. These aneurisms are found with extreme rarity in other organs. Charcot and Bouchard, who were the first to recognize them as the cause of hæmorrhage, regard them as due to chronic periarteritis, which leads to an excessive proliferation of nuclei in the lymphatic sheaths and walls of the vessels, and sometimes to atrophy and disappearance of the muscular coat. These writers believe that the implication of the tunica intima, which is always present in such cases, is secondary to the affection of the outer walls. Eichler believes that the process is an endarteritis, beginning in the intima, and then spreading outward.

These aneurisms are always very minute, and sometimes cannot be seen without the aid of a lens. Charcot and Bouchard noticed that they manifested a predilection for certain parts of the brain, being found with diminishing frequency in the following regions: Optic thalamus, corpus striatum, cerebral cortex, pons Varolii, cerebellum, centrum ovale, peduncles, and medulla oblongata. In the very large majority of cases they are situated in the corpus striatum and optic thalamus, thus explaining the great preponderance of hæmorrhages in this locality.

It has long been thought (and many clinicians and pathologists hold this view at the present time) that atheroma of the cerebral vessels is one of the main causes of cerebral hæmorrhage. But this view is erroneous. Atheroma of the brain is confined usually to the arteries of the circle of Willis, and it is not uncommon to find these vessels as rigid and unyielding as pipe-stems, without a trace of hæmorrhage in the brain. In rare cases, even the vessels of the pia mater have been found to be exquisitely atheromatous, although no vascular rupture had occurred. On the other hand, it is not uncommon to find extensive hæmorrhage, although atheroma of the vessels is entirely absent or very slight.

Age is an important factor in causation, the large majority of cases occurring after the age of forty-five years. But cases are not very infrequent at an earlier period, and they may also occur in infancy and childhood. Billard found a clot in the left corpus striatum in an infant three days old.

Heredity also appears sometimes to play a certain part in etiology, but it acts by inducing the development of miliary aneurisms, and not by giving rise to any defect in the cerebral tissues proper.

The disease also occurs quite frequently, during the course of Bright's disease, associated with hypertrophy of the heart without valvular lesion. It has been supposed that the cardiac hypertrophy and consequent increased arterial pressure, are the active factors in this condition, but it is more probable that they act only as exciting causes, the real cause being found in the changes in the walls of the vessels (arterio-sclerosis), which constitute an integral part of Bright's disease.

In scurvy, leukæmia, hæmophilia, and severe infec-

tious diseases, minute cerebral hæmorrhages may occur as the result of the nutritive changes induced in the walls of the vessels, but these will not be considered in this article.

Violent muscular strain, mental excitement, cold baths, etc., are also adduced as causes, but they only prove efficient if a lesion of the vessels is present. They probably act by causing active or passive cerebral congestion.

The large majority of cases occur in the male sex, the predisposing and exciting causes being more frequent in males than in females.

PATHOLOGICAL ANATOMY.—If the patient dies soon after the occurrence of a cerebral hæmorrhage, a soft, black clot is found, which can be readily removed from its cavity, and is usually mixed with shreds of brain-tissue intermingled with blood. The surrounding tissues are irregularly torn, and are softened and blood-stained for some distance around the clot. Very little fluid blood is present (*vide* Plate III., Figs. 1 and 2). The size of the clot varies from a minute speck (capillary hæmorrhages) to a mass of enormous size, which may occupy a considerable portion of one lobe. In the latter event the blood usually ruptures into the lateral ventricle, may then pass into the opposite lateral ventricle, and also force its way through the third into the fourth ventricle. More rarely the hæmorrhage breaks through the cortex and appears under the pia mater, usually upon the convexity. When the hæmorrhage is large in amount, pressure-effects are distinctly perceptible. The convolutions may be flattened, the falx cerebri pushed forcibly toward the opposite side of the brain, and even the nerves flattened at the base of the brain. In such cases the cerebral tissues are usually very dry.

If the loose clot is gently removed and the tissues slowly moved to and fro under water in order to remove the more adherent shreds, we shall usually be able to find the artery upon which the ruptured miliary aneurism (sometimes more than one) is situated.

After a variable period, depending chiefly upon the size of the clot, the latter begins to contract, finally breaks down, as it does in other localities, and absorption then begins. The extent to which this occurs varies in different cases. Sometimes the absorption is complete and perhaps nothing will be left at the site of the hæmorrhage but a narrow, wavy, yellowish cicatrix, which contains a variable number of hæmatoidin crystals. The latter may also be scattered through the surrounding tissues, giving them a reddish-yellow color. In other cases the serum is not absorbed, and a cavity remains which may be lined with a delicate cyst-wall. After the lapse of time it often becomes difficult, sometimes impossible, to distinguish these cysts from the remains of spots of softening.

The changes described run their course in a short time. The clot remains soft for three or four days; absorption then becomes active and reaches its maximum toward the close of the second week. If absorption is not complete, the cavity contains serum by the twentieth day, and the cyst-wall is fully formed in from four to six weeks.

Hæmorrhages within the region of the pyramid tracts, in any part of their course (and also those in the motor regions of the cortex), give rise to secondary descending degeneration, which extends down through the crus, pons, and medulla into the antero-lateral column of the opposite side of the spinal cord. In very rare cases the degeneration finally extends into the anterior gray horns of the cord.

Among twenty cases of descending degeneration of the spinal cord due to unilateral lesions of the brain, Pitres found four cases in which the degeneration was present in both lateral columns, though more markedly on the side opposite to the cerebral lesion. He attributes this remarkable phenomenon to very incomplete decussation of the pyramid tracts in the medulla oblongata—the variability of which has been clearly demonstrated by Flechsig.

Almost all cases of old hæmorrhage which have come under our observation on the *post-mortem* table, have exhibited, irrespective of the site of the lesion, an atrophy of the brain. This is observed throughout the entire cerebral hemisphere on the side of the hæmorrhage, and in the opposite hemisphere of the cerebellum. The atrophy of the latter is proportionately less marked than that of the cerebrum, but it appears to affect all parts alike. The cause of this phenomenon is obscure, but it is due probably to partial disuse of the structures implicated.

SYMPTOMATOLOGY.—In the majority of cases there are no precursory manifestations of this disease. When they are present, they consist of vertigo, headache, ringing in the ears, general mental inertia, occasional lapses of memory, and defective speech. Sometimes slight numbness and a feeling of weakness may be felt upon one side of the body. The latter symptoms are generally dependent on a slight hæmorrhage which has already occurred. The other prodromal symptoms are supposed to be due to congestion of the brain.

As a rule, however, the symptoms begin quite suddenly. In a considerable proportion of cases the attack develops during sleep, the patient going to bed in his usual condition of health and awaking in the morning to find himself paralyzed on one side of the body. When the attack occurs during waking hours, the patient generally experiences a strange sensation in the head and an increasing feeling of numbness and weakness on one side. This is followed rapidly by loss of power on that side, and the patient, if standing, falls to the ground, and in a certain proportion of cases becomes unconscious. It must be remembered, however, that a large number of patients retain their consciousness throughout the entire seizure. Thus it has been noticed that even twenty-four hours have elapsed from the onset of the symptoms to the development of complete hemiplegia and aphasia, the patient retaining consciousness and the use of his mental faculties during this entire period. The disturbance of consciousness in different attacks presents all possible grades from this condition to complete and profound coma.

In the most severe cases the patient lies motionless, with a turgid, sometimes livid face, the pupils varying but usually presenting no characteristic appearance, the cheeks flaccid and flapping loosely with respiration. The pulse is usually slow, full, and hard, the arteries of the neck pulsate visibly. Respiration is usually slow, labored, and attended with stertor; sometimes Cheyne-Stokes respiration is observed and is usually of fatal import. All the limbs may be in a condition of complete resolution, but more commonly the non-paralyzed side manifests a slight rigidity.

A not infrequent symptom of the apoplectic seizure is the so-called conjugate deviation of the eyes and head. Both eyes are usually turned away from the paralyzed side, "as if looking toward the site of the lesion." Nystagmus movements may be noticed at times, but the axes of the eyes are not directed beyond the median line. The head is also turned in the same direction as the eyes, and offers distinct resistance when an attempt is made to restore it to the normal position. In extremely rare cases this symptom has been observed in attacks of cerebral hæmorrhage unattended with loss of consciousness.

This peculiar phenomenon is usually noticed when the hæmorrhage occurs in the corpus striatum or its vicinity, although it is also observed at times when other parts of the brain are implicated. According to Hughlings Jackson, conjugate deviation is of evil prognostic import with regard to the recovery of the paralysis.

When the hæmorrhage ruptures into the ventricles, or through the cortex beneath the pia mater, contractures or convulsions are frequently noticed. Pitres states that this symptom depends upon the point of rupture of the hæmorrhage into the ventricle, and is only produced when the fronto-parietal fibres are involved by the lesion.

It has been stated that severe hæmorrhages are attended invariably by an initial depression of temperature (one-fourth to one-half hour after the beginning of the seizure), followed in a few hours by a rapid rise, which continues until death in fatal cases, and subsides after a few days in the non-fatal cases. In some instances the temperature may rise from the very beginning, even though the disease has a rapidly fatal termination.

The cutaneous and tendon reflexes are usually abolished or greatly diminished during the period of coma.

PLATE III

Fig. 4.

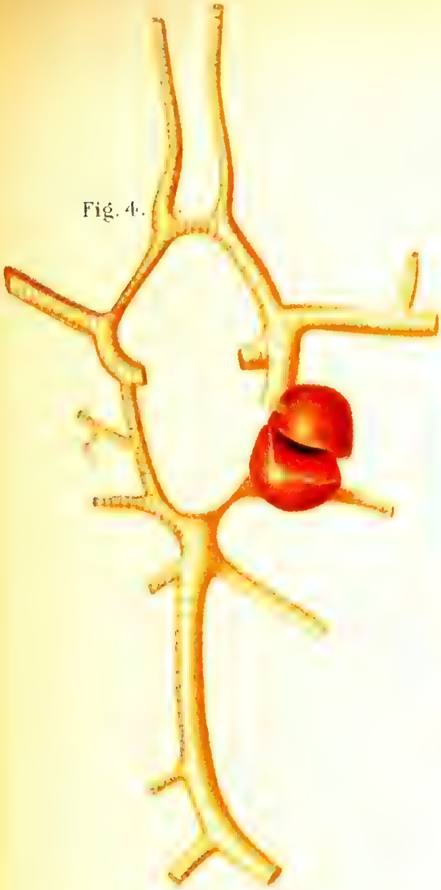
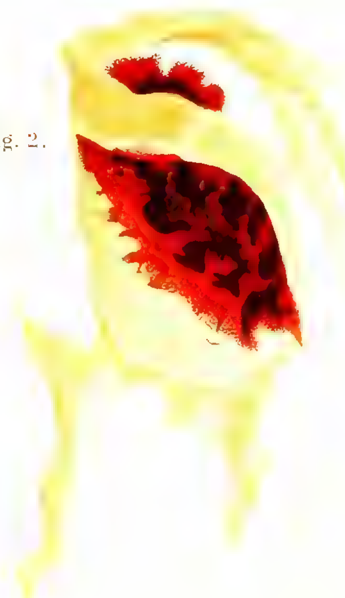


Fig. 3.

Fig. 1.

Fig. 2.



But this condition soon gives place to an increase of reflex excitability, with the exception of the cremaster and abdominal reflexes, which are found to be diminished.

As a general rule, the patient slowly rallies from the comatose condition, consciousness being restored usually in a period varying from an hour or more to a couple of days. When consciousness is restored, the paralysis present is more clearly defined, and is found to consist, usually, of hemiplegia of motion, frequently associated with aphasia when situated on the right side of the body.

In a considerable proportion, perhaps the majority, of cases it is found, when the patient returns to consciousness, that sensation is also somewhat impaired on the paralyzed side. In addition it is not rare to find that hemi-anæsthesia of the special senses, associated with hemiopia, is also present. Gowers thinks that the latter symptom can be detected, in the majority of cases, during the first period after the attack. We have verified this observation in a number of instances. As a rule, the sensory disturbances disappear almost entirely within one or two weeks, though exceptionally they continue permanently, while the motor symptoms clear up in great part or entirely.

In the majority of cases improvement continues uninterruptedly after the restoration of consciousness until a certain definite degree of paralysis is left over. In a small proportion of cases, however, symptoms of cerebral irritation, probably owing to the development of encephalitis around the clot, make their appearance at the end of a week or ten days, sometimes as early as two or three days, after the occurrence of the hæmorrhage. The patient then complains of severe headache, the temperature again rises, irritability, and even delirium may supervene. These symptoms may increase in severity and a fatal termination ensues, or, after lasting for a week or more, they may gradually disappear, leaving the patient in about the same condition as before the relapse. In some cases, rigidity or contractures develop during this condition, and subside with the other symptoms.

Acute decubitus (bed-sore) may also develop during the early period of the attack. If this occurs, it will be found usually, from the second to the fourth day, that an erythematous patch appears upon the middle of the gluteal region of the paralyzed side, followed rapidly (usually the next day) by the formation of bullæ, and then by rapid sloughing of the parts. According to Diprat, the acute bed-sore is sometimes observed upon the healthy side. Charcot states that death almost always occurs in such cases.

Vaso-motor symptoms may also be noticed from the very onset of the attack The paralyzed side is then warmer to the feel than the non-affected side, and is covered with more profuse perspiration; sometimes the radial pulse is fuller on the hemiplegic side; slight œdema of the skin on this side is also often noticed. These symptoms disappear in proportion as the coma subsides, and, at a later period, may give place to vaso-motor symptoms of a different character, which will be mentioned later.

After the immediate effects of the hæmorrhage have passed off, the patient may live for years without a recurrence. Subsequent attacks usually occur, however, unless the patient dies from an intercurrent disease.

The hemiplegia left over after an ordinary attack of cerebral hæmorrhage presents the following characteristics:

The paralysis is not so well marked, as a rule, in the face as in the limbs. There is less expression and power of motion in the lower half of the paralyzed side of the face than on the opposite side, the naso-labial fold is partly or entirely effaced, and the angle of the mouth droops and sometimes is drawn closer to the median line. The frontalis and orbicularis palpebrarum usually act as well as those on the non-paralyzed side, though careful observation often shows that they do not contract quite as vigorously as normally. This is particularly noticeable if the patient be directed to close only the eye of the paralyzed side. The paralysis of the lower half of the face becomes more marked during voluntary movements, while in laughing both sides of the face may contract to an equal degree. Some difficulty in mastication may arise from the accumulation of food between the teeth and cheek of the affected side; more rarely there is slight disturbance of deglutition. The tongue, when protruded, may deviate to the side of the paralysis on account of the unopposed action of the genioglossus muscle on the healthy side. It must be remembered, however, that this deflection of the tongue may be more apparent at times than real, and that it may be owing to the closer approximation of the angle of the mouth to the median line. If the hemiplegia has occurred in early childhood. it is commonly found after the lapse of a few years (the interval being shorter the earlier the age at which the hæmorrhage occurred) that the bones of the skull and face on the paralyzed side are slightly smaller than those on the opposite side. The muscles are also atrophied to a slight extent.

Apart from aphasia, the discussion of which will be found in the first part of this volume, speech is usually not affected very much, though sometimes there is considerable thickness and slowness of speech from the diminished mobility of the tongue and lips, or perhaps from the impairment of mental power.

The upper limb is usually paralyzed to a greater extent than the lower limb, *i.e.*, the latter recovers much more rapidly and thoroughly than the former. The upper limb, as a rule, is partially flexed in all the joints, and the arm drawn alongside the chest. The power of executing coarse movements returns first, the delicate manipulations of the fingers being restored last. The tendon reflexes at the bend of the elbow and the wrist are increased.

In walking the lower limb drags along the ground, and there is an evident effort in propelling it along. It is swung more at the hip, and the pelvis is raised higher upon the paralyzed than upon the non-affected side in order to allow the drooping toes to clear the ground.

As an almost invariable rule in adults the paralyzed limbs do not undergo any noteworthy atrophy, although the paralysis may have lasted for years; the subcutaneous adipose tissue may disappear to a considerable extent. In rare cases, however, rapid atrophy takes place, sometimes even within a few months, and is more marked in the upper limb. It is supposed that this peculiar feature is owing to the implication of the anterior gray horns as a secondary result of the descending degeneration of the lateral columns. In one case under our observation the diagnosis of this secondary change in the cord was verified by the post-mortem examination.

In hemiplegia of early childhood marked atrophy of all the tissues of the paralyzed limbs always takes place, or, at least, their growth does not correspond with that of the healthy side. Sometimes this atrophy is so marked as to look, at the first glance, like that resulting from acute infantile paralysis.

The paralyzed limbs are usually cool to the feel, and the skin may present a dusky, mottled appearance from impaired circulation; not infrequently the radial pulse is smaller than on the other side.

In addition to these vaso-motor disturbances, trophic changes may also occur, and are more marked in the upper limb. The integument sometimes seems to be thinned and atrophic, in other cases it appears thicker than normal. The nails may become discolored, lose their gloss, and become rough from excessive development of longitudinal striations. The joints, particularly the shoulder, hip, and fingers, not infrequently become affected. The joint-affection is very rarely acute in its origin. When this does occur, phenomena not unlike articular rheumatism are developed. This form usually begins in from two to four weeks after the apoplectic attack. Much more frequently, however, chronic, slowly progressing changes arise. The articular ends of the bones then appear to enlarge, and at the same time a certain amount of atrophy appears in the muscles surrounding the joint. No exudation can be detected, but the joint is very tender on pressure, and may be so painful on movement that the mobility is interfered with out of all proportion to the actual loss of muscular power. This con-

dition is extremely obstinate, and frequently resists all forms of treatment.

Late rigidity, or contracture, is a very frequent sequel of hemiplegia. The upper limb is involved to a much greater extent than the lower limb. As a general rule the fingers are strongly flexed, sometimes bent forcibly into the palm of the hand; the wrist is flexed upon the forearm, and the latter is pronated and at the same time slightly flexed on the arm. Contracture of the pectoralis major muscle draws the arm against the chest. In the lower limb the contracture is confined chiefly to the muscles of the calf, which draw up the heel.

It is very often found, even in advanced cases, that the contracture disappears in great part when the patients awake in the morning. Then the fingers, which could not be extended previously without a very great effort on the part of the physician, are relaxed spontaneously, and the patient may even be able to execute voluntary movements. In a little while, however, the *status quo ante* is restored. This condition is always attended by a marked increase of all the tendon reflexes, and sometimes by increased mechanical excitability of the paralyzed muscles. It is generally believed that this form of contracture is due to descending degeneration of the lateral columns, but this view is not well founded. We have seen one case in which the contracture was absent, although well-marked descending degeneration was found at the autopsy. Were this theory true, the symptom in question should be present in all cases of hæmorrhage or other lesion affecting the pyramid tracts, but in reality it is not infrequently absent under such conditions.

The phenomenon known as "associated movements" is also observed quite often in hemiplegia, particularly when it occurs in childhood. As a rule, strong voluntary effort on the part of the non-paralyzed limbs is associated with an involuntary movement of the paralyzed parts. Much more rarely a vigorous attempt to move the paralyzed muscles is attended with an involuntary movement of the healthy side.

Post-hemiplegic chorea is another peculiar phenomenon, allied perhaps to the associated movements just referred to. It occurs with greatly preponderating frequency in the hemiplegia of childhood, but is observed not very rarely in adults. The period of its development varies greatly, but it never occurs until a very considerable amount of improvement has taken place. This symptom is also found to be much more severe in the upper than in the lower limb.

The movements are manifold in character. Sometimes they can be distinguished in no respect from ordinary chorea, and as in the latter disease, in some cases, the movements are increased on effort; in others they are diminished.

More rarely tremor is produced like that seen in paralysis agitans, or the movements may be coarser. Some cases have been observed in which the movements were of an ataxiform character, and it is even claimed that true ataxic disturbances may be produced. There is very little doubt that athetosis (slow, constant alternation of flexion and extension of the fingers, with corresponding movements, perhaps, in the upper portions of the arm, more rarely in the lower limb, particularly the toes) is merely a variety of post-hemiplegic chorea, though it may also occur independently of cerebral hæmorrhage.

In children, in whom post-hemiplegic chorea is of very frequent occurrence, this symptom often becomes complicated with epileptiform convulsions, affecting at the onset only the paralyzed side, but later spreading usually to the other side.

Diagnosis.—The recognition of cerebral hæmorrhage is often attended with great difficulty, and indeed may be impossible. The disease is most frequently mistaken for cerebral embolism, since the symptoms of both affections may be identical. In such cases a provisional diagnosis can only be made from attendant circumstances. Embolism is usually associated with cardiac valvular disease, thrombosis of the heart, or aneurism of the arch of the aorta. As a matter of course, however, the existence of these lesions does not preclude the occurrence of cerebral hæmorrhage. If the coma occurs with great suddenness, it is due more probably to embolism than to hæmorrhage, and this is also true if the patient recovers, within a week, a considerable amount of power in the paralyzed side. Again, embolism is comparatively more frequent before the age of forty, though, as we have seen above, hæmorrhage may also occur at any age, even in infancy and childhood. The determination of the coexistence of chronic interstitial nephritis favors the diagnosis of hæmorrhage, on account of the vascular lesions so often present in the former disease. On the other hand, it must be remembered that the mere presence of albumen in the urine during an apoplectic attack possesses no significance whatever.

Cerebral hæmorrhage must also be distinguished from cerebral thrombosis. In the latter affection, the comatose condition, if it develops at all, is usually much slower in its onset, though it must also be remembered that exceptionally the symptoms of thrombosis occur with great suddenness. The disease is peculiarly an affection of old age, and the radial, temporal, and other superficial arteries are generally found to be very atheromatous. When the thrombosis is the result of a syphilitic affection of the vessels, it is almost always preceded by another train of symptoms, a discussion of which will be found under the head of syphilitic lesions of the cerebral vessels.

Hæmorrhage into the pons may also be mistaken for opium-poisoning, if it is attended, as is usually the case, with strongly contracted pupils. In the former affection, however, the pulse and respiration are not so notably retarded as in the latter, and the coma is more profound. Epileptiform convulsions, also, are not an infrequent accompaniment of pons hæmorrhage, and do not form a part of the history of opium-poisoning. Of course the obscurity is cleared up if the patient recovers consciousness.

When the hæmorrhage occurs during infancy or childhood, the disease must also be differentiated from tubercular meningitis. This affection may also be attended with unconsciousness and sometimes distinct hemiplegia, even in cases in which the autopsy shows a tolerably uniform distribution of the lesion over both hemispheres of the brain. Meningitis, however, is attended with more marked prodromal symptoms than cerebral hæmorrhage; the hemiplegia, if present, is not very profound, and is variable in degree at different times, as are also the other symptoms of the disease. In adults, meningitis rarely simulates the history of cerebral hæmorrhage.

But however careful we may be in the observation of the symptoms and of the attendant circumstances, very many cases will be encountered in which the diagnosis remains doubtful or is only cleared up by a post-mortem examination. Indeed, as was remarked in the paragraph on the pathological anatomy of the disease, even a post-mortem examination, if made long after the attack, may fail to decide the nature of the affection.

Even if a diagnosis of cerebral hæmorrhage has been made, it is extremely difficult to localize the lesion accurately with any degree of certainty until the general pressure symptoms have cleared up, leaving only those which are due to the local lesion.

In the large majority of cases the most that can be done during the comatose stage is to determine the side on which the hæmorrhage has occurred. The opposite side of the body is usually more relaxed than the non-paralyzed side, is often warmer, and the reflexes are entirely abolished; if conjugate deviation of the eyes and head is present, it is directed usually toward the side of the lesion. After the coma and the general-pressure symptoms have subsided, localization of the lesion must be determined according to the principles laid down in this Handbook under the headings, Brain, Diagnosis of Local Lesions in, and Cerebral Cortex, Function of.

If the coma is very profound, and rigidity or convulsions make their appearance at the onset, together with serious respiratory and circulatory disturbances, the hæmorrhage has probably occurred into the lateral ventricles (from surrounding parts). Hæmorrhage into the pons is

frequently attended by marked contraction of the pupils and profound coma, and when the paralysis can be determined, it is usually found to be alternate, *i.e.*, the face is paralyzed on one side, the limbs on the opposite side.

PROGNOSIS.—This varies according to the size and situation of the hæmorrhage. Other things being equal, life is more endangered the larger the hæmorrhage. However, even hæmorrhages of small size, if situated in the pons Varolii or medulla oblongata, are apt to prove rapidly fatal, and hæmorrhages in the latter locality very rarely terminate in recovery. The fatal event is due to direct interference with the functions of respiration and circulation. Cheyne-Stokes respiration is an extremely unfavorable symptom, and is almost always a precursor of impending dissolution.

Large hæmorrhages into the hemispheres, or those which rupture into the ventricles, also prove fatal, usually by direct or indirect pressure on the centres of the pons and medulla. The more sudden the development of coma, the smaller the chances of recovery. Acute decubitus, which occurs during the comatose stage, is almost invariably followed by death. The coexistence of Bright's disease is also a very unfavorable complication.

As regards the extent of recovery from the paralysis, very little can be foretold in the first period of the disease. In the large majority of cases the sensory disturbances disappear in great part and very rapidly.

Power of motion is usually restored much more rapidly in the lower than in the upper limb. When the reverse obtains, it has been generally held that an unfavorable termination will ensue, but this opinion does not appear to be well substantiated.

The occurrence of late rigidity must be regarded as an unfavorable symptom, insomuch as it interferes, in the first place, directly with the power of motion, and, in the second place, improvement in the latter usually ceases with the appearance of the former. This also holds good of post-hemiplegic chorea.

Symptoms of mental deterioration are usually permanent, and indeed, in many cases, are steadily progressive. As a rule, however, it is only after repeated attacks that a condition of mental impairment, amounting even to imbecility, develops. In very exceptional instances, epilepsy follows cerebral hæmorrhage.

TREATMENT.—Prophylactic treatment is practically nil. If the prodromal symptoms are prolonged, the patient should be kept as quiet as possible, mentally and physically, and care taken that the bowels be kept thoroughly open. When the onset of a hæmorrhage has been suspected, I have been in the habit of putting my patient to bed for a week, giving bromide of potassium in fifteen to thirty grain doses, t.i.d., and a mild laxative or enema daily.

If the hæmorrhage has taken place or is occurring at the time the physician is called, very little, if anything, can be done to check it. Drugs given internally for this purpose do more harm than good. The most that should be done is to keep the head slightly elevated, and if the carotids and temporals are pulsating strongly, apply cold applications to the head or leeches to the forehead. If the pulse continues strong during the comatose stage, nothing more need be done. When evidences of heart-failure arise ammonia and stimulants are indicated.

After the stationary stage of paralysis has developed, treatment is useless until after the lapse of a considerable period. The natural tendency of the paralysis is toward improvement (though complete recovery hardly ever occurs), and until this tendency becomes manifest, we may rest satisfied either that motor fibres are cut across or that pressure is still exerted at the site of the lesion, thus interfering in this manner with nervous conduction.

Almost the only means at our command to hasten recovery is the use of electricity. This may be employed in two ways, either to the brain itself or directly to the paralyzed parts.

The former method has been very little used hitherto, and, indeed, it is not probable that much good can be expected from it. The galvanic current alone is used for this purpose. The positive pole is usually applied to the side on which the hæmorrhage took place, the negative pole on the opposite side of the head. The current should be mild, and should never be allowed to produce vertigo; the sittings should not exceed from two to five minutes in duration.

The ordinary method (and the one which promises by far the best results) of employing electricity in hemiplegia is the direct application of the faradic current to the paralyzed muscles. It has generally been held that this measure should not be employed until at least two to three months after the occurrence of the hæmorrhage, for fear of causing a recurrence of the disease. There is very little reason, however, to doubt that this fear is entirely unfounded, and that it is perfectly safe to begin the treatment within two or three weeks after the stationary period has begun.

The strength of current employed should be merely sufficient to produce distinct contraction of the paralyzed muscles, the sittings may be held every other day, and their duration may vary from five to fifteen minutes.

In a few cases an astonishing degree of improvement occurs after the first two or three applications, after which very little, if any, progress is made. As a rule, however, improvement, if it occur at all, is very gradual, and the treatment must be continued patiently for months.

When contractures of the paralyzed limbs have developed, another method should be employed. The one usually adopted is the application of the stabile galvanic current through the nerves and muscles (nervo-muscular current) of the flexor aspect of the limbs (the parts in which the contracture is usually situated) and the faradic current to the antagonists. Warm baths and massage are also useful for this purpose.

In some cases painful swelling of the joints is extremely annoying to the patient, and this complication is very intractable to treatment. It is best combated by the use of a strong stabile galvanic current passed directly through the joint, with the addition of repeated small blisters over the site of pain.

Iodide of potassium, in doses of from five to ten grains t.i.d., is usually administered as a matter of routine, but it is more than doubtful whether this drug exerts any beneficial effect.

In our hands ergot has never given good results, no matter in which stage of the disease it has been employed. Careful attention should always be paid to the condition of the bowels, particularly as the patients are apt to be constipated for a long time after the attack.

Leopold Putzel.

BRAIN: CEREBRAL VESSELS, SYPHILIS OF. Syphilis of the cerebral vessels may affect only one vessel or almost all the arteries at the base of the brain.

The lesions in question consist of grayish or whitish thickenings of the coats of the vessel. Unlike atheromatous changes they are sometimes confined to one side of the vessel, into which they may grow, and thus produce either complete or incomplete occlusion. Usually the entire circumference of the vessel is affected, and in advanced cases the artery may be converted into a cord of almost fibrous feel. In addition, the affected vessels may be the site of thrombi.

In another series of cases the vessels are affected secondarily to syphilitic lesions, such as meningitis or gumma, in the immediate vicinity. In such an event the artery may be simply compressed, or the syphilitic new growth may proliferate into the wall of the vessel, and finally break through the tunica intima into the lumen.

According to Heubner the arterial affection develops in the following manner: The vessel becomes less transparent and somewhat whitish, finally grayish white; it then becomes cylindrical in shape and very rigid. Upon transverse section the lumen of the vessel is found narrowed by new-formed tissue, which develops between the elastic lamella of the tunica intima and the endothelium. The new tissue consists at first of endothelium cells, which continue to proliferate and change into a firm connective-tissue consisting of spindle and stellate cells, into which round cells emigrate from the nutrient vessels of the ar-

tery. In its further course the new growth either organizes into a structure similar to that of the wall of the vessel, and the process then comes to an end, or complete obliteration takes place, after cicatrization and transformation into fibrous tissue.

Baumgarten entertains different views with regard to the histological changes occurring in this lesion. He describes a case under the title "obliterating inflammation of the cerebral vessels with arteritis and periarteritis nodosa gummosa." The changes in this case were due to periarteritis and endarteritis. The characteristic features were: the nodular thickenings of the adventitia in the higher grades were entirely similar to those of the smallest gummata on account of the central cheesy and fatty degeneration, while the endarteritic proliferation in advanced stages assumed a fibrous appearance, but showed no fatty or atheromatous patches. According to Baumgarten this form of disease belongs anatomically to Friedlaender's arteritis obliterans.

Although the specific nature of these vascular lesions may be questioned from an anatomical standpoint, there is very little room for doubt that in the overwhelming majority of cases, if not in all, the changes in question develop upon a syphilitic basis. It must be remembered, however, that the diagnosis of their syphilitic nature may be made more readily from the gross appearances than from a microscopical examination.

Etiology.—Syphilitic changes in the cerebral vessels are associated usually with other syphilitic lesions of the brain, and generally occur in the later (tertiary) stages of the constitutional disease. A number of examples have been reported in which the cerebral symptoms developed in quite an early period of the secondary stage of syphilis, but, so far as we know, these cases were not the result of lesions of the vessels.

In one case, marked arterial changes were presented by a girl of fifteen months suffering from hereditary syphilis. In this case the dura mater was smooth and pale, the pia mater presented numerous circumscribed patches over the cerebral lobes. There was slight thickening around the large arteries at the base of the brain, and the majority of these vessels were thickened and hard. The basilar artery was completely plugged, and the upper part of the vertebral arteries contained tolerably soft thrombi.

Syphilitic vessel-lesions appear to be situated mainly in the middle cerebral arteries and their branches, though other vessels (notably the basilar) are often implicated.

It is very probable that mental overwork, prolonged worry, and excitement may act as exciting causes for the localization of the effects of the syphilitic virus in the brain. A few cases have been reported in which injuries to the head appeared to act in a similar manner.

It is a peculiar feature of syphilitic lesions of the nervous system—at least such has been a frequent observation in my own somewhat extended experience in these disorders—that the symptoms of the secondary stage of the constitutional disease very often are entirely, or almost entirely, absent, so that we may be compelled to rely upon the grouping of the cerebral symptoms in arriving at a diagnosis of the previous infection.

In the majority of cases the disease of the vessels is not the sole syphilitic lesion present in the brain. As we have stated above, the vascular disease itself may be propagated from a specific lesion (gumma, meningitis, pachymeningitis) situated in the neighborhood of the vessels. As a matter of course, when considerable narrowing or thrombosis of the vessel is produced, softening of the brain will occur as in similar lesions owing to other causes.

Further experience has only served to confirm the statement made by me several years ago, that cerebral syphilis appears to be growing less frequent, and that this fact is probably owing to the more vigorous and prolonged treatment of syphilis now in vogue.

Clinical History.—In pure cases of syphilis of the cerebral vessels, the symptoms are the same as those of vascular obstruction from other causes.

Prodromal symptoms, such as pain in the head, impairment of memory, giddiness, numbness, or weakness of one side of the body, etc., may be present for a long time. When the vessels supplying the pons or medulla are implicated, glycosuria or even albuminuria may precede more serious symptoms for a considerable period.

Sometimes the only prodrome noticeable, for quite a while before the advent of other symptoms, is an inexplicable fear "that something is going to happen," and this feeling sometimes causes great mental depression.

In a considerable proportion of cases, however, the symptoms referable to obstruction of the vessel develop quite suddenly (sometimes as rapidly as in cerebral embolism) or within one or two days. The patient is then found to be suffering from hemiplegia, associated quite frequently, if the paralysis is on the right side of the body, with aphasia. In the majority of cases which have come under my observation, consciousness was retained, either entirely or partially, during the attack. Aphasia is not infrequently the sole symptom of an attack of this kind.

The hemiplegic attacks may be repeated from time to time; a patient under my observation had five attacks, in one of which both sides of the body were paralyzed in rapid succession.

The subsequent history of the paralysis may differ in no respect from that produced in cerebral embolism or hæmorrhage, but in a considerable number of cases temporary recovery occurs very rapidly. As a rule, however, relapses appear after a longer or shorter interval.

In a paper published two years ago, I reported four cases of hemianæsthesia and hemiopia due to cerebral syphilis, and in one of these cases there can be little doubt that the symptoms were due to a lesion of one of the branches of the middle cerebral artery.

A characteristic phenomenon of a small series of cases is a peculiar drowsiness, which may continue even for several months. The patients go about as if "in a haze," their movements, both mental and physical, being slow and deliberate, as if consciousness, before struggling to the surface, had to overcome some unusual resistance. In some cases deep coma develops, from which it may be impossible to rouse the patient for days and days, or this condition may alternate with periods of delirium.

Diagnosis.—As syphilitic disease of the cerebral vessels is associated so often with syphilitic lesions of other parts of the brain, it will be well to mention the diagnostic features of cerebral syphilis in general.

Headache is an extremely frequent symptom, and is commonly observed at the very onset, before the appearance of any other signs indicative of a serious implication of the nervous centres. The pain is usually of a boring, pressing, often agonizing character, with marked nocturnal exacerbations, as a rule, though an exceptional course is not very infrequent.

The occurrence of cortical epilepsy in a syphilitic subject is also very significant. This variety of the disease may begin either with convulsions or paralysis, though the former symptom occurs much more frequently at the beginning. The convulsions, at least at the outset, are limited to one side of the body, and may even be much more circumscribed, attacking either the face, arm, or leg, or, perhaps, involving only a small group of muscles. After the attacks have lasted for a variable period, they may become more general, and finally extend over the entire body.

As a rule, it is found that the convulsion spreads in a definite manner from one group of muscles to another, and that the mode of progression remains the same in subsequent attacks.

Consciousness is often retained throughout the convulsive seizures, though it is generally lost when the convulsion extends to both sides of the body. After each attack, slight paralysis may develop in those parts which have been the site of the convulsion. This paralysis may disappear in a little while, but it grows more profound after subsequent spasms, and finally may remain permanently.

Another important sign of cerebral syphilis is the heterogeneous character of the symptoms (paralysis of cerebral nerves, hemiplegia, aphasia, convulsions, etc.), a fact which is naturally due to the varied character of

the lesions present in the brain. In many cases of cerebral syphilis the secondary manifestations of the constitutional disease are very slightly marked, so that they may have been unnoticed by the patient, and as the initial lesion is often disregarded, he may be unaware of his infection with the specific virus. But so significant are the heterogeneity and anomalous distribution of the symptoms, that the existence of syphilis should be suspected in every case of nervous disease in which the symptoms appear to be due to an organic affection and are grouped in an irregular and anomalous manner. Buzzard says: "I should not take much account of this absence (of syphilitic symptoms) if there were other reasons for strongly suspecting syphilis, for we are continually meeting with cases in which the symptoms caused by lesion of some part of the nervous system constitute of themselves the only testimony to the specific nature of the disorder, and experience shows these to be quite as pathognomonic as affections of the skin."

In making a diagnosis of syphilis of the cerebral vessels, as distinguished from other syphilitic lesions of the brain, special stress should be laid upon the absence of irritative symptoms. The localization of the lesion in the individual arteries will depend upon the same factors as in ordinary cerebral embolism and thrombosis. The problem is frequently complicated, however, by the coincident affection of several vessels, and perhaps by the existence of other syphilitic lesions.

The sudden development of aphasia during the course of cerebral syphilis, without previous convulsive seizures and with no evidences of cardiac disease, is also a strong indication of a syphilitic affection of the middle cerebral artery. Syphilitic aphasia is not by any means an infrequent symptom.

The peculiar form of somnolence to which we called attention in the section on symptomatology, also seems to be quite significant of disease of the vessels, although rigorous proof of this proposition, based on observations in the dead-house, is still lacking in positiveness.

As a matter of practical experience, however, it will be found in a considerable number of cases that the symptoms are so varied that we must remain satisfied with the general diagnosis of cerebral syphilis, and must confess our inability to localize accurately the various sites of the lesions. The problem of regional diagnosis is sometimes rendered so much the more difficult from the fact that in a small proportion of cases the cerebral lesions are still further complicated by the development of syphilitic lesions of the spinal cord.

PROGNOSIS.—The prognosis in syphilitic changes of the cerebral vessels is more grave than in any other form of cerebral syphilis. This is owing to the fact that, in the former event, the symptoms are caused by anatomical lesions which are not, strictly speaking, syphilitic in their character. They are the result of anæmia and necrosis of the tissues, from interference with the blood supply, in the same way that such changes follow disease of the vessels of a non-syphilitic character.

In the other forms of cerebral syphilis the lesions are purely specific, and hence it is possible that they may be removed, at least in great part, by appropriate treatment. It follows, therefore, that if the disease of the vessel has resulted in necrosis of any portion of the brain tissue, the function of the affected part cannot be restored.

Under sufficiently vigorous treatment, however, even apparently hopeless cases sometimes undergo an astonishing improvement, which may continue for a long time. In our opinion, however, complete recovery can rarely be hoped for in a case of cerebral syphilis whose history warrants us in attributing the symptoms to disease of the vessels. But in no case should we declare ourselves worsted and desist from further treatment. The greater the danger, the more urgent is the need of treatment. Even in the other forms of cerebral syphilis the prognosis is not so good as is generally believed, yet marvellous success is often achieved.

The lesions of the vessels exhibit a very great tendency to relapse after apparent recovery, particularly if treatment is not carried out with the proper vigor and persistency. Probably in the majority of favorable cases, the symptoms do not disappear entirely, particularly if the symptoms have included hemiplegia or disturbances of the mental faculties.

TREATMENT.—The treatment consists almost exclusively of the administration of anti-syphilitic remedies, and the earlier we resort to these remedies, the more assured is a successful result. Hence the extreme importance of an early diagnosis, and for this reason, also, "mixed treatment" should be employed in all doubtful cases.

More benefit can be derived from iodide of potassium in the treatment of cerebral syphilis than from the preparations of mercury, but the use of the latter should not be neglected. I found not infrequently, in former years, that a patient who had been only holding his own, or perhaps improving slowly, would grow better very rapidly when a small quantity of mercury was added to the iodide of potassium which he had been taking. In such cases, also, it may often be noticed that when mercury is added to the prescription, the dose of iodide of potassium may be diminished without being followed by a relapse.

With regard to the amount of iodide which should be administered in individual cases, we can only say that this must be regulated by the effect produced upon the patient. In rare instances (very few, indeed, have come under our notice after an extensive experience in this class of cases) the patient manifests an idiosyncrasy with regard to the drug, and cannot tolerate even small doses. In such cases very minute doses must be given, and the attempt made gradually to increase the dose. In some cases the effect desired is not secured until enormous doses (6 to 8 drachms, or even more) are given in the course of twenty-four hours. The notion is quite prevalent in the profession that doses as large as those mentioned are dangerous to the patient, but this view is not justified in the least by my own observation. It is claimed that acute nephritis may result from the large doses; but although I make it a matter of routine to examine the urine at regular intervals in such cases, I have *never* seen the slightest indication of the development of any renal disorder.

The iodide may be given in solution with water, but I often prefer the infusion of gentian as a vehicle, since this appears to counteract the tendency to gastric disturbance manifested by some patients. The drug is best given one or two hours after meals, and should always be largely diluted (one-half to one tumblerful of water, Vichy water, or milk).

In all cases of cerebral syphilis it is advisable to add some preparation of mercury to the potash salt. The bichloride of mercury, either in pill form or in solution with the potash, proves sufficient in the majority of cases. It is my usual practice to begin with one thirty-second of a grain t.i.d., and then to increase the dose gradually to a twelfth, an eighth, or even more, according to the indications in the individual case. It is a good plan to keep on increasing the dose until the gums become a little tender, and then an amount slightly smaller than that necessary to produce such an effect, may be continued for a long time. In grave cases, when we wish to overwhelm the patient, as it were, with the drug, it is better to use inunctions of blue ointment, or the oleate of mercury, which is a more cleanly preparation, though often quite inert.

If the patient is unconscious, my plan has been to administer the mercury by inunction, and the iodide of potassium by rectal injections. As much as from four to six grammes of the iodide (largely diluted with water or milk) may be injected every four hours. When the patient recovers consciousness, the drug may again be administered in the usual way.

After serious symptoms have subsided, the dose of the anti-syphilitic remedies is gradually diminished, but should be continued persistently (if possible, without intermission) for at least one or two years after the subsidence of the symptoms. The dosage required during this time varies in individual cases, but should always be sufficiently large to prevent a fresh outbreak of the disease.

I cannot express myself too strongly concerning the extreme importance of protracted treatment, and the necessity of administering the remedies in sufficiently large doses. It should be remembered that the dosage must be regulated solely by the amount requisite to control the symptoms in each individual case. Van Buren and Keyes report a case (syphilis of the buccal cavity) which was only controlled by the exhibition of two ounces daily of the iodide of potassium. As a rule, however, it will be found unnecessary to give more than an ounce a day, even in the most aggravated cases. If this dose fails to relieve the symptoms, there is rarely any chance of success.

Apart from the use of the strictly anti-syphilitic remedies, very little can be done in the way of treatment. When the pain does not yield to these drugs, opium must be resorted to, and perhaps the repeated application of blisters to the back of the neck will prove useful. Repeated convulsions are sometimes controlled by the addition of bromide of potassium to the iodide mixture.

The patients should be strictly warned against the use of alcoholic drinks in any shape, as these are very apt to aggravate the symptoms. They should also be kept as free as possible from excitement or worry, as well as from mental overwork. *Leopold Putzel.*

BRAIN, COMPRESSION OF. Notwithstanding the unhappy use of a word that does not describe the subtile condition it is meant to express, the term compression is a convenient one that seems justified by the necessities of analysis and study. It is generally used in a pathological sense to describe a complexity of symptoms arising from a particular state of the brain characterized mainly by disorder of the circulation within the cranium, and manifested by more or less derangement of the three great faculties of the nervous system.

As a principle used to account for the phenomena of brain disease, and as a complication that is often present after various lesions of the brain and its membranes, the special and differential diagnosis of compression is of no small importance, and includes a wide range of cerebral pathology. The prevailing opinions of writers on this subject are somewhat misleading, since compression, in its true sense of occupation of less space, is a condition of the brain which in most cases would seem to be assumed rather than demonstrated to exist, and it is rare to find a case of compression in which there are not present the symptoms both of concussion and laceration of the brain.

Whether the bringing together of its constituent parts or the diminution of volume that is supposed to interfere with the functions of the brain be affected by pressure from without the encephalon, or by tension within its proper substance, the condition arises from a great variety of causes, prominent among which are effusions within the skull, which may be either prompt or slow in their manifestation. The effusion may result from contusion, concussion, laceration, or traumatic inflammation of the brain and its annexes; or from cerebral hæmorrhage, meningitis, and encephalitis from internal cause; or it may result from hydrocephalus and from simple congestion. Any of the fluids that escape from the substance of the brain or its envelopes may give rise to an effusion quick or slow that may result in compression. Hypertrophy of the brain and tumors of different kinds, whether modifying the capacity of the skull by affecting its bony covering, or originating in the membranous envelopes of the brain, or in the substance proper of this organ, may likewise give rise to the disorders that characterize compression. Other causes are foreign bodies, loose splinters, or larger portions of depressed bone, effusion of blood within the skull from a wound of the middle meningeal artery, rupture of a sinus, or even the veins of the diploë, laceration of the capillaries, or of the small arteries of the cerebral substance, and, in fact, any injury of the head, whether simple contusion, scalp wound, or fracture of the skull. Whatever be the cause of compression, it should be borne in mind that the most characteristic symptoms are brought about by sudden action; compression established slowly upon the brains of animals by the injection of a liquid does not cause appreciable symptoms, unless the quantity injected be unusually large; and it should be further remembered that, in the human subject, appreciable symptoms of compression are not always induced by such causes as sanguineous extravasation into the cranium and the cerebral ventricles, nor by the pressure of a foreign body, nor by a fracture.

Loss of consciousness and paralysis, which vary according to the seat and extent of the compression, are symptomatic of the condition, no matter whether the compression be sudden, like that following a wound or some mechanical injury of the skull and its contents, or whether it be slow, as that following enlargement of the brain from extravasation of blood lymph, pus, serum, or tumors. Excepting paralysis of the eyes, this symptom is always on the opposite side to that which is the seat of injury. The symptoms may come on almost immediately after any injury of the brain which disorganizes its substance; but there are other cases in which compression takes place slowly and after a certain lapse of time. The initial symptoms that characterize this period are mainly subjective and those of congestion, as vertigo, headache, and confusion of ideas, nausea, and on rare occasions vomiting. Then follows a lethargic sleep and more or less paralysis, and the patient cannot be aroused by any stimulus. The face is suffused and dusky, it wears an expression of well-pronounced stupor, and the eyelids are usually closed and immovable; respiration is slow, labored, and stertorous, something like the act of snoring, and the peculiar blowing movements of the lips in expiration have been compared to the act of smoking a pipe. Deglutition is impossible, and the tendon reflexes are abolished. As the intracranial trouble increases the pulse becomes slow and labored. It may be hard and frequent, or small and intermittent. Sometimes it is very irregular, and the symptoms may resemble those of anæmia of the brain and medulla, brought about by experimental means. Paralysis of the sphincters is generally present, with involuntary evacuations; or the patient may have torpidity of the bowels and obstinate constipation. Retention of urine, often present from paralysis of the bladder, is followed by incontinence as the result of overflow from distention. The skin may be cool or it may be hot and perspiring, and the temperature, though generally normal, may reach as high as 106° F. One or both of the pupils may be contracted or dilated, or they may rest immobile and unresponsive to the action of light. The symptoms of choked disk may also be present, and sometimes nystagmus is noted. Paralysis both of motion and sensation, in one or both extremities, may exist in case the compression be exercised on the hemispheres, and convulsive movements and twitching of the limbs may occur on the paralyzed side or on the opposite side.

These pathognomonic symptoms, which are chiefly owing to effusion under the dura mater, or to fracture of the inner table of the skull, are not always met with, nor do such injuries as those inflicted by nails and arrowheads driven into the skull, and even missiles lodged in the brain, always produce the symptoms of compression. Sometimes the brain may be compressed without any trouble in its functions. Pressure from an abscess, causing a hollow in the brain as large as a man's fist, has been known to cause no symptom of compression. It is, moreover, doubtful whether depressed fracture be a frequent cause of compression, since the injury is always complicated by laceration, the symptoms of which are often mistaken for those of compression; and it is often difficult and always embarrassing to determine, after an injury of the head, whether we have to deal with a contusion of the brain, a simple concussion, or the more problematical symptoms of cerebral compression. One state so often merges into the other that the attempt to establish a clear basis for a sure diagnosis of the respective conditions seems hopelessly confused and intricate. Roughly speaking, the most characteristic symptom of concussion is somnolence and intensity of the evil from the outset; contusion manifests itself by agitation, delirium, convulsions, contractions, and the delay of febrile symptoms; while the most salient symptom of compres-

sion is paralysis, except in the case of effusion of blood into the convexity of the hemispheres, or into the ventricles, when contraction is the more prominent phenomenon. Without being a sure sign, paralysis constitutes at least a valuable element in the diagnosis of a condition that has no single confirmative sign. If there be an unequivocal sign of cerebral compression in the majority of cases following injuries of the head, it is, perhaps, that furnished by obstruction of the venous circulation, in consequence of which the blood of the eye is not returned into the cavernous sinus, when we find with the ophthalmoscope papillary or peri-papillary congestion, a general or partial serous infiltration of the papilla, and a strong dilatation with tortuosity of the retinal veins. In concussion the fundus of the eye retains its normal state; in compression there is always serous peri-papillary infiltration, dilatation, tortuosity, and sometimes thrombosis of the veins of the retina.

According to many observers, the general symptoms of compression are owing to cortical anæmia, and the general impairment of cerebral function is owing to disturbance in the capillary circulation, which prevents the normal interchange between the blood and the tissues, and results in physiological death to the affected portion of the brain. Mechanical impairment of circulation in the cortex would seem to account for the comatose condition in cerebral compression, and the hemiplegia found in uncomplicated compression can be ascribed only to fatal crowding of the blood out of a superficial portion of the brain. In compression, the blood may be extravasated upon the surface of the brain, the effusion taking place between the skull and the dura mater, and in the cavity of the arachnoid, or in the intervening spaces that separate the membranes from the brain, or it may be effused into the ventricular cavities, or into the substance proper of the brain. The volume of an extravasation between the dura and the bone is sometimes very large; but, as a rule, effusions of this kind are always much larger at the vault of the cranium than at its base. Sanguinary effusions between the dura and the bone, according to the summarized opinions of writers on the subject, generally coagulate into a firm clot that may either be absorbed or undergo organization and become adherent to both the bone and the dura mater. This clot never becomes encysted like clots in the cavity of the arachnoid, but may undergo ossification. It is also susceptible of change, and may lead to necrosis of the neighboring bones of the skull, which may be perforated by an abscess having as its foyer the sanguineous effusion.

Blood extravasated between the layers of the arachnoid, especially on that part covering the cerebrum, is of common occurrence in the severest head injuries, and forms at the convexity of the hemisphere a thin, evenly spread layer. It clots rapidly, loses its coloring-matter, undergoes organization, assuming this form of false membrane, or of a membranous cyst, and may be absorbed and take on a secreting action like other cysts.

Effusions between the visceral layer of the arachnoid and pia mater are less common than those in the cavity of the arachnoid, and are generally associated with some injury of the brain itself. They spread extensively into the spaces usually occupied by the cerebro-spinal fluid, and do not become encysted as in other situations.

Traumatic effusions into the brain-substance may occur in any situation. They are generally associated with laceration or other severe injury of the brain, and are for the most part fatal. Should recovery take place, the blood-clot undergoes changes similar to those observed in the organization of an ordinary clot from cerebral hæmorrhage.

All effusions of the blood between the dura mater and the brain are susceptible of being reabsorbed, of being encysted in a false membrane, and of giving place to encephalitis, meningitis, and other grave symptoms that come eminently within the province of surgery; in fact, it is chiefly from this point of view that compression has been treated by the great masters.

Compression, whether produced by depressed bone, extravasation of blood, inflammatory exudation, the formation of pus within the skull, or by the lodgement of foreign bodies, has no order of appearance, no well-defined progress, no increasing or decreasing evolution of symptoms, since other complications habitually coexist with the condition, making it difficult to distinguish the part that each takes in the symptoms observed. The interval of consciousness, more or less complete, and the symptoms of concussion that precede the coma and hemiplegia after an injury to the head, enable us to diagnose meningeal extravasation without laceration of the brain-substance. Absence of the conscious interval, the presence of the immediate symptoms of compression, with restlessness and excitement, generally incomplete paralysis, with convulsive movements and twitching of the limbs, denote that the extravasation is cerebral; that is, that the hæmorrhage is dependent on laceration of some portion of the brain, and that the extravasation has taken place into its substance.

There is a similar absence of conscious interval—the symptoms of compression being immediate—after a depressed fracture or the lodgement of a foreign body within the skull. It is not till the third day, at earliest, that symptoms of compression occur from inflammatory exudation, and it is usually ten or fourteen days after the receipt of an injury that the formation of pus within the skull may give rise to the symptoms of compression. This condition is preceded by inflammation of the brain or of its membranes; that is, by considerable pyrexia, great heat of head, intolerance of light and sound, and more or less delirium. Rigors often occur in the latter stages of the inflammatory process, and are usually diagnostic of commencing suppuration. What is known as Pott's puffy tumor is a valuable indication of the formation of pus within the skull. The difficulties become greater when it is a question of localizing the encephalic lesion, since the indications are founded in part upon results obtained by experiments on animals, which are rarely confirmed clinically, and cannot, therefore, be considered as diagnostic signs.

In place of attributing many of the troubles grouped under the subtile heading of compression to pressure exerted upon the brain, it would be better to attribute them to congestion, to contusion, and to laceration of the cerebral substance, which puts us in a position to doubt whether the effects of compression upon the brain are not susceptible of further and more convincing proof.

The integrity of the brain is not compromised by compression itself, nor is the condition a very fatal one. Its gravity depends on the consecutive inflammations. Sometimes the symptoms disappear spontaneously and gradually, without interference.

The treatment of compression raises many questions of operative interference, which are discussed elsewhere under their respective headings. The whole end of treatment is, however, to prevent cerebral inflammation, in endeavoring to do which an opportunity is offered, in most cases, to distinguish one's self in a diagnostic rather than in a therapeutic way. *Irving C. Rosse.*

BRAIN, CONCUSSION OF. CAUSES.—Concussion of the brain may be produced by any form of violence which results in a shock to the contents of the skull. One of the most common causes is a direct blow, as when a person is struck on the head with a club or other instrument. Falls are very common causes of concussion, either from the head striking on the pavement or other object, or from transmitted violence, as in landing on the feet. When in the latter instance the violence is sufficient to cause concussion of the brain, it is very likely to fracture the base of the skull.

SYMPTOMS.—When a patient is suffering from a severe and recent concussion of the brain, unconsciousness complete or partial will be almost invariably noticed; thus a person is frequently said to be "stunned" by a blow on the head or a fall. With this unconsciousness there may be paralysis, partial or general, or convulsive twitchings of certain groups of muscles. The temperature of the body will be lowered, the skin being distinctly cool to the touch. The pulse will generally be slow and intermit-

tent. The respiration will be slower than normal and somewhat labored; it may be irregular and sighing. The features will probably be contracted; there may be twitchings of the facial muscles. The condition of the pupils will vary; in one set of cases they will be contracted; in another set dilated; these changes may be unequal. In still other cases one pupil may be contracted and the other dilated; occasionally but one pupil will be affected. The symptoms will frequently be accompanied by some external mark of violence about the head, as a contusion or wound. Hæmorrhage of the nose, throat, and ear was reported in one case as occurring after concussion (*London Medical Gazette*, 1832). When the concussion is slight, temporary complete or partial loss of consciousness may be the only symptom; this may be accompanied by some loss of power. Loss or impairment of sight, and loss of memory occasionally occur after the concussion; the suspension of the normal functions, however, does not last long. In one instance occasional convulsions occurred after concussion, lasting for ten days, and followed by complete recovery. In another case, aphonia, loss of taste, hearing, and vision, with dysæsthesia of lower extremities occurred after concussion.

Reaction.—When the patient is going to recover there will appear, after a time, varying from a few hours to a day or more, a period of reaction. The skin will become warmer, the features less contracted, the respiration more regular, and the pulse steadier but more rapid. Vomiting very often occurs at this point; this symptom is not alarming, but is of some importance, it being the first result of a more active circulation through the cerebral centres. If the case is to terminate favorably the patient will now rapidly recover his faculties and strength, perhaps being rather dull and heavy, and indisposed to exert his mind or body for a few days. If, however, the case is to terminate unfavorably, the symptoms may pass into those of meningitis, or encephalitis from excessive reaction, or into those of compression of the brain. When compression is the sequel, the unconsciousness will become deeper, passing into complete insensibility, coma, and death; a relapse into unconsciousness may occur without indicating special danger, but it should always excite apprehension. When an inflammatory affection is to be the sequel, it will be indicated by a very rapid pulse and an increased rise in the temperature; there will be also, of course, the other usual signs of meningitis or of inflammation of the brain-substance.

Pathology.—The actual changes in the substance of the brain caused by concussion vary with the intensity of the force applied. Dr. Agnew ("Principles and Practice of Surgery") describes four different forms: (1), cerebral vibration without visible lesion; (2), vibration followed by sero-sanguinolent transudation; (3), vibration attended with extravasation of blood; (4), vibration with laceration of the brain-substance. In the second form, he says, the patient will lie with the limbs flexed, with more or less irritability, and perhaps, muscular tremor; there will probably be involuntary evacuations. The third form frequently passes into encephalitis, which will appear on the fifth or sixth day.

The post-mortem appearances in a fatal case of concussion may be negative, in which case the only structural lesion was a *vibration* of the brain-substance; in many cases there will be found great congestion of the vessels of the brain; in others there will be points of extravasation throughout the brain-substance, and in others the brain may have a distinctly bruised appearance. When there is a large amount of blood effused it may be situated at the point where the violence is applied, or, by "contre-coup," on the opposite side of the brain (this is also true of the other changes). The effusion may take place at any point in or on the brain; effusion frequently occurring in the ventricles.

Diagnosis.—The condition with which concussion of the brain is most likely to be confounded is compression of the brain. The symptoms of compression are generally those of apoplexy; hence, in it, we have the characteristic state of the pupils and the peculiar respiration of apoplexy with hemiplegia or convulsions, and a full slow pulse. The symptoms of concussion appear immediately after the receipt of the injury; those of compression come on some time afterward. The impairment of consciousness, sensation, and motion, is much deeper in compression; in concussion the patient can generally be roused by speaking to him. There is no vomiting in compression, and the bowels and bladder will be paralyzed. In concussion deglutition is only impaired, in compression it is destroyed.

In some cases, however, it is impossible to establish a differential diagnosis between concussion and compression of the brain.

It may be difficult to distinguish concussion from apoplexy or alcoholism (or even from opium or uræmic poisoning), when a history of violence is wanting; but this is rarely the case. An alcoholic condition often masks the condition of concussion, and has been the cause of serious mistakes. In cases complicated by alcoholism, the patient should be treated as if he or she had sustained a concussion, until the state of alcoholism passes off and an accurate diagnosis can be made.

In cases in which opium poisoning is suspected, we must judge principally by the history, the respiration, the state of the pupils, and the presence of any suspicious substance. The urine should always be drawn and tested for albumen in order to exclude uræmic coma.

Prognosis.—The prognosis of concussion, when there is no change in the brain-substance beyond a vibration or temporary congestion, is good, the patient beginning to improve a short time after the injury. When meningitis, encephalitis, or compression is developed, the question of recovery becomes a very serious one.

Restlessness and screaming, when associated with a very rapid pulse, and occurring after a concussion, indicate laceration of the brain-substance, and almost always precede a fatal termination (Agnew: "Principles and Practice of Surgery").

Sequelæ.—There are certain "remote effects" of concussion which are occasionally developed. Insanity has developed in patients who had sustained a concussion, even when the recovery was apparently complete; the mental alienation not making its appearance for weeks or months afterward.

Impairment of sight, with loss of power and sensation, has occurred after concussion, the lesion probably being, as was supposed, an impairment of nutrition of the brain-substance near the tubercula quadrigemina (*Med. and Surg. Reporter*, 1878). Suppurative action, as one of the sequelæ of concussion, may occur in some distant organ (*Lancet*, 1840). Hemiplegia, cerebral abscess and softening have occurred as the results of concussion (*Association Med. Journal*, 1855). One case of supposed complete recovery, was followed by a fatal relapse due to abscess of the brain (*London Med. and Surg. Journal*, 1832). Impairment of memory has also occurred after concussion of the brain.

Treatment.—Ordinary cases of concussion of the brain require very little treatment; still, any case of injury to the brain should be dealt with as if it might become serious. The patient should be kept quiet, on a moderate diet, and with very little stimulants generally. In some cases, when the collapse is profound, artificial warmth must be applied to the body, as by the hot-air bath; brandy and water, or whiskey and water, should be given in small quantities, and ammonia applied to the nostrils. Cold water, or the ice-bag, should be applied to the head constantly. After the collapse has passed off, the treatment should be such as to prevent the reaction from becoming too intense.

Mental as well as bodily rest must be insisted on; the head must be kept cool, if necessary it should be shaved, and the bowels should be emptied by a saline laxative or a mercurial purge.

If the reaction be excessive, counter-irritation may be made behind the ears or at the nape of the neck; leeches may be applied to the temples, or behind the ears. If the pulse be full and rapid, venesection may be performed at the onset of this stage.

The diet should be liquid, milk being the most beneficial.

William H. Murray.

BRAIN, DEVELOPMENT OF THE. Historical Notes.—Tiedemann (1816) observes that Coiter (1572) was the first to recognize the embryonic brain vesicles. We find Coiter's observation adopted or independently confirmed in the writings of Harvey (1651), Steno (about 1660), Malpighi (1672), and Haller (1758). All but the last two of these authors seem to have held the erroneous view that the vesicles were closed sacs, with cavities completely separated from each other. Von Baer (1837) largely laid the foundation of the true view of the continuity of the vesicular cavities, and their identity with the medullary canal on the one hand, and the adult encephalic ventricles on the other. His views were confirmed, with slight modifications, by those of Bischoff (1842) and Remak (1851), and, in major part, are generally accepted at the present time. They may be briefly stated as follows: That the medullary tube first divides into three vesicles; the foremost of these subdivides into the fore-brain and 'tween-brain; the second remains the mid-brain; the hindmost divides into the hind-brain and after-brain; these divisions correspond approximately to the cerebral hemispheres, the optic thalami, the optic lobes, the cerebellum, and the medulla oblongata. Reichert (1859) accepted most of Von Baer's views, as also did Kölliker (1861), in the first edition of his "Embryology." In 1877 appeared Mihalkovic's valuable work, giving a full history of brain growth, and, among other points, insisting that the cerebral vesicle is not formed by the subdivision of the primary fore-brain, but is a new forward

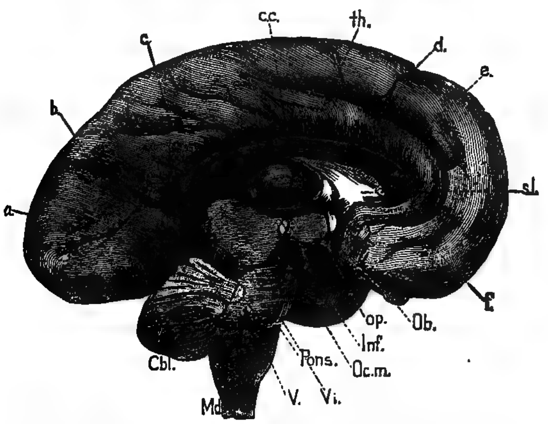


Fig. 500.—Mesal View of the Brain; Human Fœtus, about Six Months. The corpus callosum has been divided, and the right *crus cerebri* cut through, so as to remove the right hemisphere and leave the other parts intact. *a, b, c, d, e, f*, cerebral fissures; *c.c.*, corpus callosum; *th.*, optic thalamus with the middle commissure; *s.l.*, septum lucidum; *Ol.*, olfactory lobe; *op.*, optic nerve; *Inf.*, infundibulum; *Ocm.*, oculimotor nerve, *Pons*, pons Varolii; Vi., sixth, V., fifth nerve; *Md.*, medulla; *Cbl.*, cerebellum. (Minot.)

growth. Kölliker, in the second edition of his "Embryology" (1879), accepted Mihalkovic's views in general, but questioned his statement that the cerebral vesicle is a new forward growth. Goette (1875) and Loewe (1880), in an elaborate work, combated the views formerly accepted, maintaining that the true segmental division of the brain is three-fold; that the cerebral vesicle is, from the first, the upper portion of the primary fore-brain; finally, that there is no real subdivision of the primary hind-brain. These views (Loewe) are expanded in the descriptive part of this article. They differ from those held by such authorities as Balfour ("Comparative Embryology") and Thompson (Quain's "Anatomy," ninth edition). In the later stages of brain growth there is less room for discussion. Ecker (1868) published a valuable monograph upon the development of the cerebral cortex; while we largely owe to Flechsig (1876) our knowledge of the development of the nerve-fibre courses. The knowledge of histogenesis, or the origin of the nerve-tissues, is still in an unsatisfactory state.

Introductory.—The first steps in the development of the cerebro-spinal axis are taken when the three embryonic layers, epiblast, mesoblast, and hypoblast can first be distinguished. Surpassing most other organs in the rapidity of its growth, we find that at the eighth month the fœtal brain shows all the adult features in their simplest expression. Our knowledge of the initial stages of brain growth is chiefly derived from the embryos of lower animals, especially of the chick, pig, and rabbit, as up to the present time we have no satisfactory accounts of human embryos younger than two weeks; but as all the higher vertebrates resemble each other closely in their early development, we may take it for granted that the early stages of the human brain do not widely differ from those of these lower forms. We may follow the nomenclature adopted in Quain's "Anatomy" as fairly representing the accepted standard among anatomists. In the description of early stages, it is necessary to substitute the adjectives *dorsal* and *ventral* for posterior and anterior, as used in adult anatomy, since the embryonic axis is in a horizontal, not a vertical plane. The adjective *anterior* will accordingly indicate the cephalic, as distinguished from the *posterior*, or caudal end. In the later stages of development, however, as the brain acquires its adult form, it is found easier to employ the adjectives of position in their ordinary acceptation.

Outline of the Whole Period of Development.—The first stage of development consists in a series of changes in the ectodermic cell layer, which result in a continuous plate of thickened cells extending from the cephalic to the caudal region—the foundation of the brain and spinal cord. Down the axial line of this plate a groove extends, from before backward, and this is followed by the folding up of the sides of the plate to meet at the top and form the neural tube, the cavity of which becomes the ventricles of the brain, and *canalis centralis* of the spinal cord. At, or even before the completion of the tube, three swellings appear in its anterior region; the foremost is at the end of the tube, and is called the primary fore-brain, the others being known as the mid- and hind-brains. These swellings mark off the brain region from that of the cord. The hind-brain now subdivides, and the fore-brain gives off two lateral swellings, the optic vesicles. The anterior wall of the fore-brain then grows forward, constituting a fifth, or cerebral vesicle. The embryonic neural tube is thus divided into five little swellings, which indicate the five great segmental regions of the adult brain. In the meantime, a great downward bending of the two foremost vesicles has begun, and causes them to lie at an acute angle with the hindmost vesicles, forming the cranial flexure. The walls of the neural tube are still uniformly composed of elongated epiblast cells, but they now grow unevenly, at some points thickening rapidly, at others becoming thinned; yet to follow these changes the primitive tubular condition must be kept clearly in mind. From this point onward, the development of the different segments must be described separately. The fourth and fifth segments form, in the roof, the cerebellum and tela vasculosa, and in the floor, the pons Varolii and medulla oblongata. The mid-brain, or third segment, has the simplest history; the roof forms the optic lobes, the floor becomes the crura cerebri, and the cavity forms the iter. The second segment, or primary fore-brain, gives rise to the optic thalami, by a thickening of its lateral walls; its cavity persisting as the third ventricle, while the dorsal and ventral walls remain comparatively thin, and undergo a series of remarkable changes, to form the pineal gland above and the infundibulum below. With the latter is connected the pituitary body, or hypophysis. The foremost segment, or cerebral vesicle, gives rise to paired outgrowths, the walls of each of which are divided into a basal stem and dorsal thinner area, the mantle. The stem becomes the corpus striatum, and the mantle the cerebral hemisphere of the same side. Between the hemispheres two commissures appear subsequently, the anterior commissure and corpus callosum, and at the same period with the latter arises the fornix. Upon the external surface of the hemispheres appear the gyri and sulci, as foldings in part of the whole hemisphere wall, in part of the cortex only. At an early stage the brain is surrounded by a delicate vascular membrane derived from

the mesoblast, the pia mater. At several points the brain-wall becoming exceedingly thin and closely uniting with the pia mater, is thrust in upon itself into the ventricles to form the various choroid plexuses. Finally, step by step with the changes outlined above, histological changes of great complexity have been going on, so that from the simple double row of cells constituting the primitive wall of the neural tube, arise the fibrous and cellular elements of the adult brain through changes only a part of which are well understood.

The above outline will make clear the following divisions in the treatment of the subject: 1. The early development of the neural tube as far as the completion of the encephalic segments. 2. The special history of each of the encephalic segments. 3. Histogenesis, or the origin of the brain-tissues, including the epithelial lining of the encephalic cavities. 4. Comparative anatomy and general conclusions.

I. The Neural Tube and Encephalic Segments.

The central nervous system, as well as the nerves and sense-organs, are wholly derived from the *epiblast*, or outermost embryonic layer. This layer is folded in along the dorsal axial line of the embryo, forming a tube, which is first covered with the epidermic stratum of epiblast, then surrounded by the mesoblast, in which the skull and vertebral column are formed, so that we soon lose sight of the important fact that the inner or ventricular surface of the brain and spinal cord was originally part of the outer body surface of the embryo. When the nervous epiblastic stratum begins to be differentiated, an important structure, the notochord, appears in the axial line beneath it. This lies in the centre of the cranio-vertebral axis and terminates abruptly in front beneath what will become the mid-region of the brain. It is part of the skeletal system.

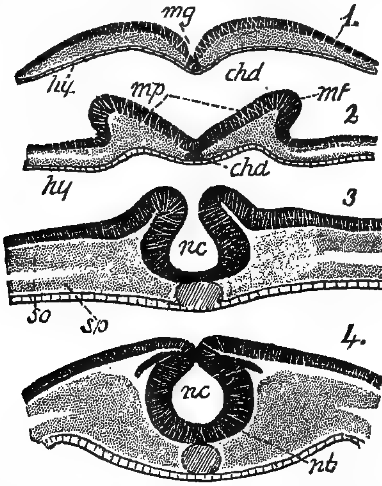


Fig. 501, Nos. 1 to 4.—Transverse Sections through the Medullary Plate and Neural Tube of an Embryo Bird. *chd*, Notochord; *hy*, hypoblast; *mf*, medullary folds; *mg*, medullary groove; *mp*, medullary plate; *nc*, neural canal; *nt*, neural tube; *so*, somatopleure; *sp*, splanchnopleure. (Mihalkovics and Balfour.)

The Medullary Plate (Fig. 501, No. 1).—The medullary groove is a long, shallow furrow, which appears along the dorsal line. For a short space upon either side of it the vertical epiblast-cells are elongated and in some cases reduplicated to form the *medullary plate*. This plate is raised in front from the remainder of the flat embryonic area by a transverse fold, the *head-fold*. There next appear in the anterior third of the plate two lateral *medullary folds* (Fig. 501, No. 2), which extend slowly forward and backward parallel with the groove. At about this period the epiblast surrounding the embryo splits into an outer, epidermic, and inner nervous stratum. It is doubtful, in the embryos of mammals and birds, whether the splitting occurs over the region of the plate, although the division clearly occurs early in the epiblast at the sides of the plate.

The Neural Tube (Fig. 501, Nos. 3 and 4; Fig. 502, No. 5).—The folds rise rapidly at the sides and deepen the primitive shallow groove. They finally meet and coalesce at the top, forming a tube, closed above and still open at the ends. This closure is first effected on the ninth day in the rabbit in the region of the mid-brain, and it extends forward and backward, completing the closure of the entire encephalic portion of the medullary plate, while the spinal cord region is still an open groove. The walls of this tube are of approximately uniform diameter, and its lumen is a vertical oval; above it is closed in by the epidermic stratum of epiblast; below it rests upon the notochord; at the sides are the plates of mesoblast.

The Primary Encephalic Vesicles (Fig. 502, No. 6).—The above account holds true for birds and the lower vertebrates, but in the rabbit and probably in man the segmentation of the encephalic portion of the neural tube into three vesicles and the budding of the optic vesicles precedes the complete closure of the medullary folds. According to Kölliker, Goette, and Rabl Rückhard, there first appears a median constriction, dividing the whole encephalic region into two vesicles. The posterior vesicle soon subdivides, so that three swellings are apparent, which mark respectively the primary *fore-*, *mid-*, and *hind-brain*. These consist simply of alternate expansions of the walls of the tube; of these the fore-brain is the largest, and even before its closure above, its side-walls expand laterally to form the optic vesicles, so that these are distinctly outgrowths of the most anterior portion of the brain at this period.

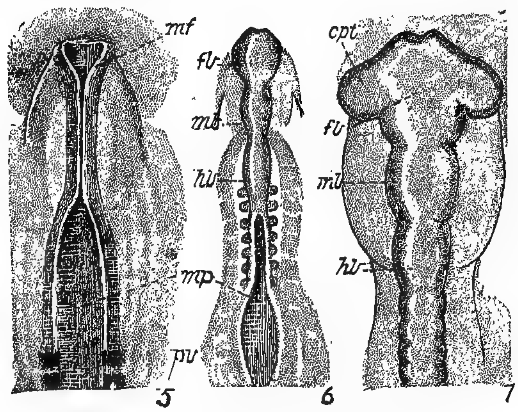


Fig. 502, Nos. 5 to 7.—The Medullary Folds and Encephalic Segments of an Embryo Bird. (Kölliker.) *fb*, Fore-brain; *hb*, hind-brain; *mb*, mid-brain; *opt*, optic vesicles. Other letters as above.

The Five Encephalic Vesicles (Fig. 502, No. 7; Fig. 503, Nos. 8 and 9).—The above segmentation may be called primary, as the segments which now appear are formed by secondary subdivision of the fore- and hind-brain. There is first a four-vesicle stage. At this period the optic vesicles have extended outward and backward, the mid-brain is a short and simple dilatation, and the hind-brain is long and narrow, not sharply defined from the spinal cord. The latter divides into a short anterior and long posterior swelling, the hind and after-brain of German authors, or the epen- and metencephalon. The mid-brain, or mesencephalon, undergoes no subdivision. The terminal wall of the primary fore-brain now extends forward as an unpaired vesicle, the secondary fore-brain, which, since it is a new outgrowth, differs in its development from the three primary vesicles. The secondary fore-brain (Fig. 503, No. 10), or prosencephalon, as it gives rise to the hemispheres, is also known as the cerebral vesicle. The primary fore-brain, or 'tween-brain, receives the segmental name of diencephalon.

We must now look at two parallel features of development which begin at this period and progress rapidly dur-

ing the subsequent stages. These are the optic vesicles and the encephalic flexures.

The Optic Vesicles (Fig. 502, No. 7; Fig. 503, No. 9).—Prior to the formation of the cerebral vesicles, the optic vesicles extend outward from the forward half of the lateral walls of the primary fore-brain. They at first open widely into the cavity of the fore-brain (Fig. 509, Nos. 30 and 31), but gradually extending outward, they form two primary optic vesicles, connected with the brain by an optic stalk, which retains at first a narrow slit-like lumen. During this process the cerebral vesicle has begun to develop rapidly from the anterior dorsal region of the primary fore-brain, so that the primary vertical half of the anterior encephalic wall is thrust downward to form the optic nerve-plate, which marks the position of the later developed optic chiasma and forms the ventral boundary between the cerebral vesicle and the primary fore-brain. The optic stalks (Fig. 504, Nos. 15 to 18) now have a minute opening into the lower sides of the primary fore-brain, while the optic vesicles extend downward and backward, and secondary changes occur by which they are infolded to form the retina and pigment-layer of the

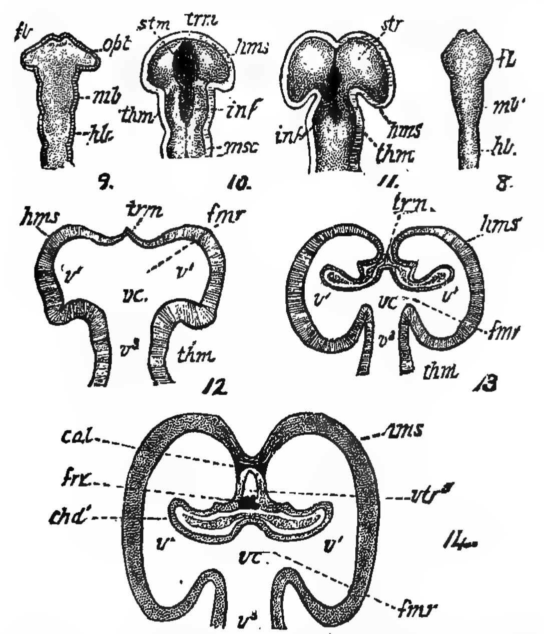


Fig. 503, Nos. 8 to 14.—Horizontal Sections of the Fore-brain (8 and 9 of a bird; 10 to 14 of a rabbit). (Kölliker, Mihalkovics, Löwe.) *cal*, Corpus callosum; *chd*, choroid plexus; *fmr*, foramen of Monro; *frx*, fornix; *hms*, cerebral vesicle; hemisphere; *inf*, infundibulum; *msc*, mesencephalon; *stm*, stem; *str*, corpora striata; *trm*, lamina terminalis; *thm*, optic thalami; *vc*, ventriculus communis; *vtr*[5], fifth ventricle; *v'*, lateral ventricle; *v*[3], third ventricle. Other letters as above.

choroid. The history of these changes belongs properly to the development of the eye.

The Encephalic Flexures (Fig. 504, Nos. 15 to 19; Fig. 506, Nos. 20 and 21).—The cerebral vesicle does not grow forward in the same horizontal axis as the primary vesicles, but downward. Thus arises a ventral flexure which extends to the primary fore-brain, then to the centre of the mid-brain floor, giving rise to an acute angle in the encephalic axis known as the *cranial flexure,* since the entire head is bent downward. This bend is greatest at a somewhat later stage than those already described, causing the mid-brain to form the termination of the long axis of the neural tube; it apparently but not actually disappears in older embryos, owing to the rapid dorsal growth of the cerebral vesicles (hemispheres). Two other flexures of less importance appear later. The first of these, the *pons flexure*, reverses the direction of the cranial flexure, as it is a sharp downward bend of the brain-floor at a point where the pons Varolii subsequently develops. The *neck flexure* is an upward bend in the roof of the metencephalon and appears later. The pons and neck flexures reach their maximum in a seven weeks' human embryo. The cranial flexure is clearly the most important of the three, as it involves the entire head. It arises in the more rapid development of the roof of the brain-case and brain than of the floor, accompanied by a bend in the base of the brain-case. The flexure is just in front

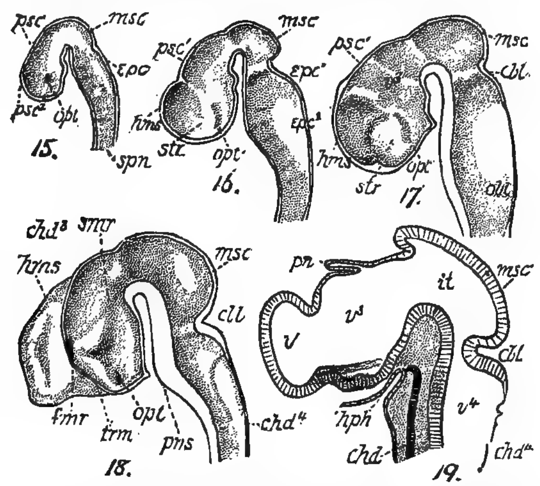


Fig. 504, Nos. 15 to 19.—Vertical Sections of the Brain (15 to 18, of the Rabbit; 19, of the Bird). (Mihalkovics.) *cbl*, Cerebellum; *chd*[4], tela vasculosa; *chd*[3], choroid plexus of third ventricle; *epc*, epencephalon; *hph*, hypophysis; *it*, iter; *psc*[2], prosencephalon; *psc*[1], diencephalon; *pns*, pons Varolii; *smr*, sulcus of Monro; *v*[4], fourth ventricle.

of the termination of the notochord (Fig. 504, No. 19), but the meaning of this disproportion in growth is not determined.

Views of Loewe and Goette.—As before said, the views advanced by Loewe upon the development of the encephalic segments differ from those which are generally held; as his conclusions, however, are supported by others, his account may be briefly stated. According to him the final division of the brain is into three vesicles (Fig. 505, Nos. 24 and 25); in the foremost of which we

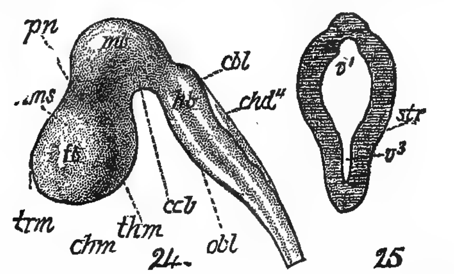


Fig. 505, Nos. 24 and 25.—Lateral View of the Rabbit's Brain and Vertical Section through the Fore brain. (Loewe.) *chm*, Optic chiasma; *ccb*, crura cerebri; *pn*, pineal gland. Other letters as above.

observe two areas, (1) an upper hemisphere area containing the wide primitive cavity of the unpaired cerebral vesicle; (2) a lower area, that of the optic thalami, containing a narrow cavity, the future third ventricle and infundibulum below. The figure shows the relations of these parts at the period of the cranial flexure, indicating the various points at which the structures characteristic of the roof and floor will subsequently appear. When the flexure is complete, it will be seen that the cerebral vesicles are already anterior to the region of the thalami. There now occurs an elongation of the roof in front of the pineal body; in this way the anterior and upper portions of the cerebral vesicles are unrolled, as it were, so that the upper wall becomes the terminal wall, and the original terminal wall becomes part of the floor, and the

cavity of the cerebral vesicle, originally above the third ventricle, extends in front of it, while the posterior portion of the roof becomes secondarily the roof of the third ventricle. According to this view, it appears that the cerebral vesicle is present in the first formation of the fore-brain and does not consist, as Mihalkovics, Kölliker, and Balfour state, of an entirely new growth forwards. Loewe also affirms that the epencephalon of other writers is merely an hypertrophy of the anterior roof-region of the hind-brain.

SUMMARY.—Now for a brief period the brain is a tube divided into five more or less clearly distinguished vesicles. The vesicular cavities are continuous, and the walls may, for convenience of description, be divided into floor, roof, and sides, which, through uneven growth, form the adult brain. The relation of the adult to the embryonic parts is shown in this table:

Primary Fore-brain.	1. Prosencephalon. Secondary fore-brain, cerebral vesicle.	*Roof and sides:* Cerebral hemispheres. Ependyma lining the choroid plexuses. *Floor:* Olfactory lobes, corpora striata, lamina terminalis. *Cavities:* Ventriculus communis loborum and lateral ventricles. *Commissures:* Anterior commissure, corpus callosum, fornix.
	2. Diencephalon. Primary fore-brain, 'tween brain.	*Roof:* Pineal process and gland, ependyma lining choroid plexuses of third ventricle, velum. *Sides:* Optic thalami, cerebral peduncles. *Floor:* Infundibulum, tuber cinereum, posterior lobe of hypophysis, optic chiasma. *Cavities:* Third ventricle and recessus pinealis above, infundibulum below. *Commissures:* Middle commissure, supra commissure.
Primary Mid-brain.	3. Mesencephalon. Mid-brain.	*Roof and sides:* Corpora quadrigemina. *Floor and sides:* Crura cerebri. *Cavity:* iter. *Commissure:* Posterior commissure.
Primary Hind-brain.	4. Epencephalon. Hind-brain.	*Roof:* Valvula cerebelli, cerebellum. *Floor:* Pons Varolii, anterior cerebellar peduncles. *Cavity:* Anterior portion of fourth ventricle.
	5. Metencephalon. After-brain.	*Roof:* Tela vasculosa (ependyma of choroid plexus of fourth ventricle). *Sides and floor:* Posterior cerebellar peduncles, medulla oblongata. *Cavity:* Fourth ventricle.

II. SPECIAL DEVELOPMENT OF THE ENCEPHALIC SEGMENTS.

1. DEVELOPMENT OF THE EPENCEPHALON AND METENCEPHALON.—The divisions of the hind-brain are less clearly distinguished than those of the anterior segments, and their segmental character is questioned by Loewe and many other writers. The short anterior segment represents the cerebellum, and the long posterior becomes the medulla oblongata, but the floor of each is continuous and passes forward without break into the mid-brain. The metencephalon (Fig. 502, No. 7; Fig. 504, No. 15) narrows gradually into the spinal cord, and is for a short period indented at the sides by five or six faint swellings, which suggest a segmented condition. It is doubtful whether these are cases of atavism, *i.e.*, rudimentary segments, or merely mechanical effects of uneven growth. They soon disappear.

In the following history the details, except of the earliest stages, or where the exception is noted, refer to the human brain.

The Medulla Oblongata and Fourth Ventricle. — The thinning of the roof of the after-brain early divides it clearly from the hind-brain (Fig. 504, Nos. 17 to 19). As the sides spread apart the multiple cell layer of the roof is reduced to a single row of flattened cells; these are the parent cells of the delicate *ependyma*, which later unites with the mesoblastic pia mater to form the *tela vasculosa*, or roof of the fourth ventricle. At the sides, these ependyma cells become continuous with the epithelial lining of the central cavity of the brain and spinal cord. The spreading of the walls and transparency of the roof give rise to the *fossa rhomboidalis*, a triangular cavity, bounded by the cerebellum in front and narrowing behind as the sides unite in the roof of the cord. The *sulcus centralis* at the bottom of the fossa is the persistent medullary groove; at the sides of this in the fourth month appears the *eminentia teres*.

The floor of the epen- and metencephalon develops into a uniformly thick plate, and about the fifth day, in the chick, the first histological changes occur, dividing it into an upper, cellular and lower, nerve-fibre layer, continuous anteriorly with the crura cerebri of the mid-brain. The ventral fissure of the cord (*sulcus longitudinalis anterior*) is then carried along the lower surface of this plate to the pons flexure. Forward, at the sides of this fissure appear the olivary fasciculi; the lateral portions become the restiform bodies, and the longitudinal fibres of the anterior pyramids are the last to appear, in the fifth month. The above changes occur between the second and fifth months in the human embryo.

The Cerebellum and Pons Varolii (Fig. 504, Nos. 17 to 19; Fig. 506, No. 20).—The medullary roof of the hind-brain thickens rapidly, and with the broadening of the medulla oblongata arches like a band over the anterior portion of the fourth ventricle, as the *lamina cerebelli*. Posteriorly it thins off into the delicate tela of the after-brain. In this lamina the primitive cells are gradually supplanted by nerve-tissue, which extends laterally into the surrounding parts. The median lobe is accordingly the first to develop (Fig. 512, No. 37), the lateral lobes first appearing as rounded swellings (Fig. 512, No. 37*a*). About the middle of the third month four or five transverse convolutions appear in the median lobe, and in the fourth month the lateral lobes or hemispheres become more prominent, and the median convolutions, which are now more marked, extend into them. The lateral lobes now surpass the median lobe in development, and also begin to subdivide rapidly into minor lobes, the latter appearing first as simple rounded swellings, and later becom-

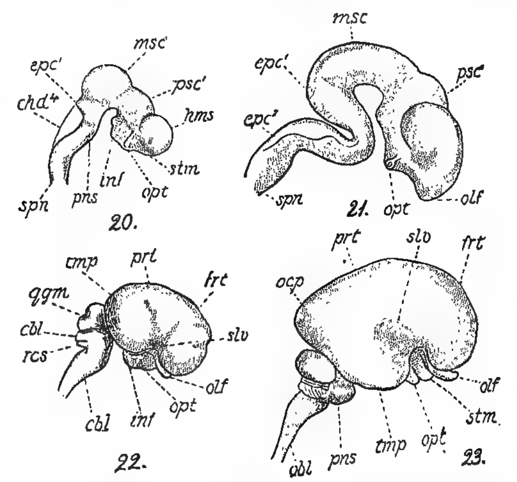


FIG. 506, Nos. 20 to 23.—Lateral Views of the Brain (20, of a Bird; 21, 22, of a Human Embryo; 23, of a Pig). (Mihalkovics.) *frt*, Frontal lobe; *ocp*, occipital lobe; *olf*, olfactory lobe; *prt*, parietal lobe; *qgm*, corpora quadrigemina; *obl*, medulla oblongata; *prt*, parietal lobe; *rcs*, recessus lateralis; *slv*, Sylvian fissure; *spn*, spinal cord; *tmp*, temporal lobe. Other letters as above.

ing convoluted. In the angle between the cerebellum and the medulla oblongata, on each side, appear three folds, which are connected with the lower lateral parts of the cerebellum. The lowest marks the lateral recesses of the fourth ventricle, while the middle is the layer of the *flocculus*, which develops later. It will be observed in the figures that the primitive lamina cerebelli passes off gently into the thin roof of the fourth ventricle: this intermediate area forms the *velum medullæ posterius*, corresponding to the *velum medullæ anterius*, or valve of Vieussens in front. By the fifth month the adult form of the cerebellum is fairly well defined, and it has estab-

lished relations with surrounding parts as follows: in the third month the restiform bodies unite with the lateral lobes of the cerebellum as the posterior peduncles; also at the angle of the ventral flexure the first transverse fibres of the *pons Varolii* arise in the floor of the hind-brain, connecting later with the middle peduncles of the lateral lobes; in the fourth month the pons becomes a marked feature of the brain-floor; in the fifth month the anterior peduncles (processus ad cerebrum) pass forward into the mid-brain, and between them the medullary roof is thinned, forming the valve of Vieussens.

2. The Development of the Mesencephalon.—This division of the brain springs directly from the primary mid-brain, its roof and sides forming the corpora quadrigemina and internal geniculate bodies; its floor developing the cerebral peduncles or longitudinal fibre courses, and its cavity narrowing relatively into the iter. When the cranial flexure is greatest, the mid-brain is a long unpaired vesicle, sharply bent around the flexure, with a swollen roof and short floor. It is well distinguished at the roof, less at the sides, and not at all at the base from the surrounding segments. The whole brain-floor from the pons region to the optic tracts enters into the formation of the *cerebral peduncles*, so they enter the floor of the primary fore-brain. They appear about the third month as two folds diverging anteriorly, and their later development keeps pace with that of the pyramidal tracts in the fifth month. Subsequently, the *substantia nigra* arises, dividing each peduncle into the ventral (*crusta*) and dorsal (*tegmentum*) region. The floor between the diverging peduncles remains comparatively thin and represents the posterior perforated space. While the roof of the mid-brain is rapidly thickening, its upper surface, for a long period, remains smooth and rounded. In the third month a longitudinal furrow appears, dividing it into two equal lobes, and in the fifth month a second furrow arises, crossing the first at right angles, dividing the roof into the *corpora quadrigemina*. In the forward portion of the roof the *posterior commissure* arises, dividing the mid- from the primary fore-brain. The cavity of the mid-brain at first opens widely into that of the adjoining segments, but with the thickening of the walls it diminishes, finally forming the narrow *iter*, which connects the third and fourth ventricles.

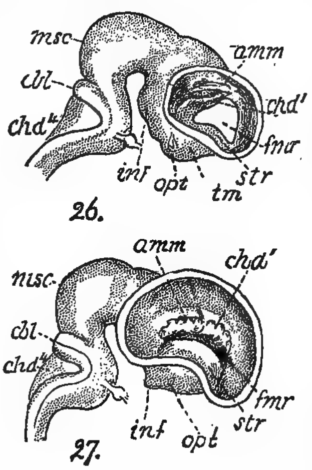


Fig. 507, Nos. 26 and 27.—Lateral Views of the Brain, with the Lateral Ventricles Exposed. (Mihalkovics.) *amm*, Cornu ammonis; *tm*, stem. Other letters as above.

3. Early Changes in the Primary Fore-brain (Fig. 501, Nos. 1 to 4; Fig. 502, Nos. 5 to 7; Fig. 503, Nos. 8 to 14; Fig. 504, Nos. 15 to 19; Fig. 506, No. 20).—The fore-brain, as has been shown, consists of the primary vesicle, from which grows forward a secondary vesicle, the prosencephalon. The latter is at first unpaired, but later it develops the paired cerebral hemispheres and structures at their base, while the primary vesicle remains single, forming the optic thalami, etc. In the first steps these segments may be treated together (Fig. 503, Nos. 10 and 11; Fig. 504, Nos. 15 and 16). They at first open widely into each other, the walls of each expanding above into the cerebral vesicle and vesicle of the third ventricle respectively. These vesicles are separated by a slight lateral constriction in the walls; this constriction does not extend into the lower portion of the brain-wall; here the cavity is narrowed by the approximation of the walls into a deep compressed area, the infundibulum, which extends along the base of both segments (Fig. 506, No. 20). The sides of this lower area in the prosencephalon constitute the *stem;* while the upper expanded walls constitute the *mantle*. In the diencephalon the upper expanded area is the *third ventricle*, the lower area is the *infundibulum*. For a brief period the entire cerebral vesicle is unpaired, then as the vesicle expands laterally the growth is arrested in the median vertical line in front. This results in the formation of a septum, the *lamina terminalis*, in the medullary wall (Fig. 503, No. 12), which is the anterior boundary of the unpaired encephalic cavities. A Y-shaped cavity is thus formed as the hemisphere vesicles bud forward, and thus early the following parts may be distinguished: the *lateral ventricles*, communicating by the *foramina of Monro* with the *ventriculus communis loborum;* the latter opens into the third ventricle. The distinction between the last-named cavities is an embryonic character of the human brain, but while the third ventricle is usually described as extending forward to the lamina terminalis, it is clear that the cavity between the foramina of Monro really belongs to the prosencephalon.

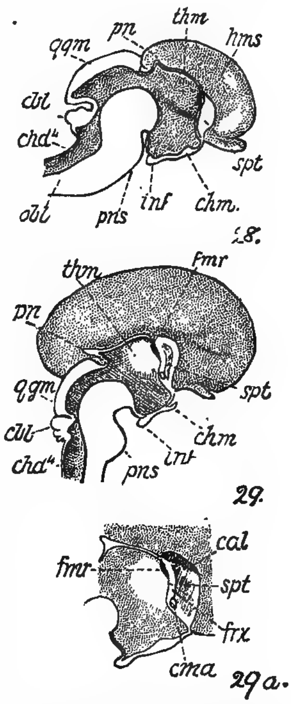


Fig. 508, Nos. 28 to 29*a*.—Vertical Sections of the Brain, showing the Development of the Corpus Callosum (Nos. 28 and 29*a*, of a Pig Embryo; 29, of a Human Embryo). (Mihalkovics and Reichert.) *chm*, Optic chiasma; *cma*, anterior commissure; *spt*, septum lucidum. Other letters as above.

4. Development of the Diencephalon.—The subsequent changes in this segment consist in the great thickening of the sides of the third ventricle, and in a comparative arrest of growth in the floor and roof, accompanied by the development of two remarkable structures, the pituitary body and the pineal body. While the mid-brain is developing, the walls of the third ventricle thicken into the *optic thalami* (Fig. 503, Nos. 12 and 13); with the growth of these bodies the primitive, wide, segmental cavity becomes a high, narrow slit, the third ventricle, continuous behind with the iter, in front with the ventriculus communis. At the same time the corpora striata are appearing in the stem of the cerebral vesicle, and as the lower outer walls develop rapidly, they grow backward around the outer ventral surface of the thalami, thus partly enclosing them, and bringing the base of the cerebrum closer to the base of the mid-brain. Thus it happens that the cerebral peduncles, which from the floor of the mid-brain develop partly in the upper walls of the infundibulum, appear to pass directly into the base of the prosencephalon. Further changes in the diencephalon are as follows: Extending along the inner surface of the thalami, from the iter to the primitive foramen Monroi, is a groove, called the *sulcus of Monro* (Fig. 504, No. 18). After the formation of the crura cerebri in the third month, this groove marks off the cavity of the third ventricle from that of the infundibulum below, and in the fifth month the thalami unite above this groove, and the *middle commissure* is formed. The thalami gradually extend upon the inner side of the corpora striata, and form a broad union with them. In the fourth month the anterior columns of the *fornix* arise in the walls of the diencephalon.

The roof of the third ventricle and floor of the infundibular region have during this period undergone a series

of changes of a remarkable character. The floor of the infundibulum is sunk between the diverging crura cerebri, and in it from behind forward the following structures appear (Fig. 508, No. 29): (1) the *substantia perforata posterior*, partly belonging to the mid-brain; (2) the *corpora albicantia*, keeping pace with the development of the fornix in the fourth month; (3) the infundibulum proper and *tuber cinereum*, bounded in front by (4) the optic chiasma. In front of the chiasma is the lamina terminalis, belonging to the cerebral vesicle; this lamina is continued upward above the ventriculus communis, into the roof of the third ventricle. In the latter, from before backward, are developed the following: (1) By changes similar to those occurring in the roof of the medulla oblongata, the anterior region of the roof is reduced to a single row of epithelial cells. The pia mater thrusts this downward into numerous folds, which compose the choroid plexus of the third ventricle. This delicate membrane in front, passing below the pillars of the fornix where it unites with the lamina terminalis, extends laterally above the foramina of Monro; posteriorly it unites at the sides with the tæniæ thalami. (2) Here it is less vascular, is known as the *velum*, and is limited behind by a delicate commissure in front of the pineal stalk (supra commissura, Wilder). (3) The middle portion of the roof is thrust upward into the pineal stalk. (4) Immediately behind this is a thickening which develops into the posterior commissure. The continuity of the primitive walls of the third ventricle thus remains unbroken.

The Pineal Body (Fig. 504, No. 19).—About the fourth day, in the chick, and at a corresponding period of development in the rabbit, the roof of the third ventricle in

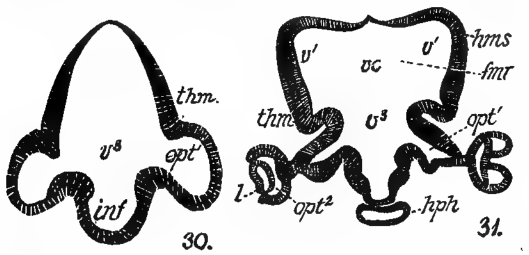


FIG. 509, Nos. 30 and 31.—Transverse Sections through the Fore-brain of a Rabbit, showing the Development of the Optic Vesicles and Rudimentary Parts of the Eye. (Kölliker). *l*, Lens; *hph*, hypophysis; *opt*¹, primary optic vesicle; *opt*², secondary optic vesicle.

front of the posterior commissure is pushed upward into the glove-finger-like process opening into the third ventricle. The lower walls of this tube contract later, so that the opening disappears, and the pineal process becomes a closed sac. The sides of this sac now expand, and give rise to a number of follicular outgrowths, indented by the highly vascular surrounding mesoblastic tissue. Finally, the cavity of the sac disappears, giving the body a compact, glandular appearance. The cells pass from a cylindrical to a polygonal shape, never resembling lymphatic or nervous tissue, but retaining rather the epithelial character of the ependyma. The pineal process probably develops in a similar manner in the human brain; it appears between the sixth and seventh weeks, directed first upward and then backward over the mid-brain, and finally overhung by the corpus callosum.

The Pituitary Body, or Hypophysis (Fig. 510, Nos. 32 to 36).—The anterior and posterior lobes of the hypophysis are widely distinct in their mode of development, the former arising from the epiblast of the mouth, the latter from the floor of the infundibulum. About the ninth day, in the rabbit, just in front of the notochord, appears a small involution in the epiblastic roof of the mouth (stomadaeum) (Fig. 510, No. 32); this extends upward toward the brain-floor, and its stalk is gradually constricted, until in the sixteenth day it forms a complete *pituitary vesicle*, connected with the roof of the mouth by a slender thread. Meanwhile, a process similar to the pineal stalk is pushed downward through the pituitary space left between the trabeculæ of the cartilaginous cranium, and joins the pituitary vesicle. The cavity of the vesicle is now subdivided into a number of branching tubules, penetrated by blood-vessels from the mesoblast; these branches ramify; the original lumen almost disappears, and the compact, anterior lobe of the hypophysis is then formed. The infundibular process also undergoes a metamorphosis, forming a solid mass of indifferent cells mixed with connective-tissue and blood-vessels, but without any nervous elements. It forms the posterior lobe of the hypophysis. (For comments upon the meaning of the pineal and pituitary bodies, see Comparative Anatomy.)

5. DEVELOPMENT OF THE PROSENCEPHALON.—In order to understand clearly the complicated changes which follow the development of the hemispheres, the following facts must be clear: (1) The hemispheres first appear as hollow, thin-walled vesicles, growing outward from the

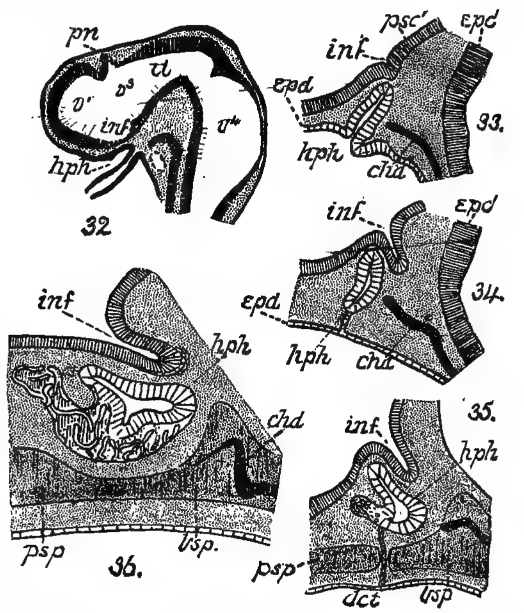


FIG. 510, Nos. 32 to 36.—The Development of the Hypophysis (32, Section through the Head of a Shark; 33 to 36, through the Infundibulum and Mouth Region of a Rabbit Embryo). (Balfour and Mihalkovics.) *epd*, Ependyma; *bsp*, basisphenoidal cartilage; *psp*, presphenoidal cartilage; *psc*¹, floor of third ventricle; *epc*¹, floor of fourth ventricle; *dct*, remnant of hypophysial duct.

primitive cerebral vesicle. (2) In the cleft between them is formed the falx cerebri. (3) Their mesal adjacent surfaces are separate. (4) They open by wide foramina into the ventriculus communis. (5) The roof of each vesicle is continuous above the foramina with the roof of the diencephalon. (6) No break in these walls occurs during the following changes. The growth of the hemispheres consists in an expansion of the mantle, first forward, then outward and downward, then upward and backward, above all the posterior encephalic segments. Secondly, the inner walls unite and fuse in front of the lamina terminalis. Thirdly, the boundary roof between the hemisphere vesicles and the diencephalon on either side is doubled in upon itself within the lateral ventricles. The actual outer surfaces of the primitive brain are thus infolded and overlaid.

Corpora Striata.—The stem of the cerebral vesicle, while still unpaired, develops a rounded swelling upon either side of the ventriculus communis (Fig. 503, No. 11; Fig. 504, No. 17); these are the beginnings of the *corpora striata*. As these swellings expand within the lateral ventricles, the *anterior* and *descending cornua* are gradually defined. As the striata develop they extend downward and backward, partially enclosing the outer

Brain.

sides of the optic thalami ; at the same time they differentiate into the *nucleus caudatus* above, arching over the *nucleus lenticularis* below. The original surface of contact with the thalami extends rapidly, the boundary becomes obscure, and the thalami finally appear as a part of the base of the hemispheres. These changes also result in the partial closure of the wide foramina of Monro, so that only the forward upper portion remains as an oval slit, bounded by the lamina terminalis, the corpora, and the thalami (Fig. 507, Nos. 26 and 27).

As the hemispheres overlap the thalami, two inward folds of the boundary roof appear upon each side, extending from a point above the foramen of Monro to the lower part of the descending cornu, and projecting into the lateral ventricle. The uppermost of these is a thickening of the mantle, forming the *cornu ammonis* (hippocampus). (Fig. 507, Nos. 26 and 27); the lowermost is an excessive thinning of the roof, forming the *choroid plexus* of the lateral ventricle (Fig. 503, Nos. 13 and 14). The latter, like the choroid plexuses described above, is thrust inward by a fold of the vascular pia mater, along what is known as the great transverse fissure. The single-layered epithelial cells covering this fold are continuous with the ependyma lining the lateral ventricles, so that there is no real interruption of the brain-wall at this fissure, as was formerly supposed. The epithelium of the upper fold passes beneath the body, posterior pillars, and fimbria of the fornix, structures which appear at the lip of the cornu ammonis. The lower epithelium of the choroid plexus unites with the inner lining of the thalamus, somewhat within the stria terminalis. From this line backward the thalami, although apparently lying within the ventricles, are in reality extra-ventricular.

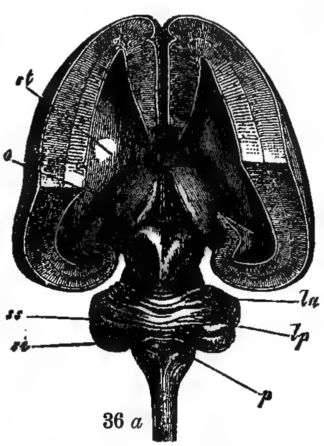


FIG. 511, No. 36*a*.—Brain of a Five Months' Fœtus, with the Upper Walls of the Hemispheres Removed. (Kölliker.) *st*, Corpora striata ; *o*, optic thalami ; *ss* and *si*, semilunares superior et inferior ; *p*, pyramid.

About the middle of the third month the median surfaces of the hemispheres, in front of the lamina terminalis, form a triangular area of union, the *septum lucidum* (Fig. 508, Nos. 28 and 29*a*). In the centre of this the vertical cavity, known as the fifth ventricle, is enclosed, which has no structural affinity to the other ventricles. In the lower posterior angle of this septum appear the transverse fibres of the anterior commissure. Then from the sides of the infundibular region of the diencephalon arch upward the fibres of the anterior pillars of the fornix, converging in the posterior part of the septum above the foramen of Monro, and diverging again into the hippocampi. According to Mihalkovics, the fibres of the *corona radiata* have appeared in the roof of the hemispheres before the corpus callosum arises. In any case, this structure, which is characteristic of a high order of brain, appears as late as the beginning of the fifth month in the anterior portion of the septum ; it extends gradually backward, with the advancing union of the hemispheres, assuming a more horizontal position (Fig. 514, No. 39), arching over the diencephalon, and finally forming the splenium. But, at the outset, the fornix and corpus callosum appear, respectively, as vertically and transversely cut fibre-bundles enclosing the small area of the septum lucidum.

The Cerebral Hemispheres.—With the growth of the corpora striata, the hemispheres assume a somewhat bilobed or bean-shaped appearance in side view, the posterior lobe lying just above and behind the corpora striata, the anterior lobe bending downward, while corresponding to the hilum is a shallow depression which constitutes the first trace of the Sylvian fissure (Fig. 506, Nos. 21 to 23). The floor of this depression is the rudiment of the *central* lobe (opposite the corpora striata), while arching around it are the still undefined areas of the *frontal, parietal,* and *temporal* lobes. The latter already overlaps the sides of the diencephalon. These simple relations obtain until the middle of the third month, then there appears a swelling between the parietal and temporal lobes, which first indicates the *occipital lobe.* At best, these divisions are somewhat arbitrary. In the second month the hemispheres cover the anterior portions of the thalami (Fig. 510, No. 36 ; Fig. 512, Nos. 37 and 37*a*) ; in the third month they reach the optic lobes, while the temporal lobes extend around the sides of these bodies. Owing to the cranial flexure, the hemispheres do not cover the optic lobes until late in the fifth month. In the sixth month they extend even considerably beyond the cerebellum, as the growth of this organ is retarded (Fig. 515, No. 45).

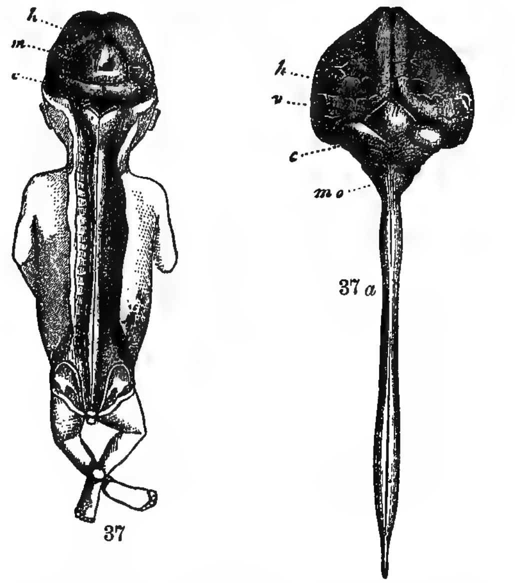


FIG. 512, Nos. 37 and 37*a*.—A Three Months' Human Embryo, with Brain and Spinal Cord Exposed. (Kölliker.) 37*a*, Brain and Spinal Cord of a Four Months' Embryo, Natural Size. *h*, Hemispheres ; *v* and *m*, optic lobes ; *c*, cerebellum ; *mo*, medulla oblongata.

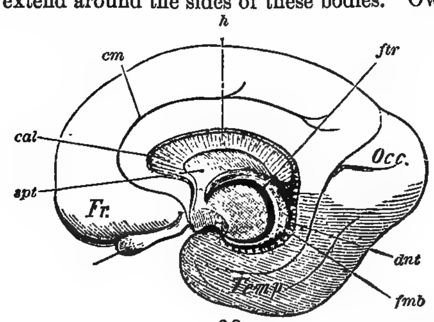


FIG. 513, No. 38.—The Right Cerebral Hemisphere of a Six Months' Human Embryo. *dnt*, Gyrus dentatus ; *fmb*, fimbria ; *ftr*, fissura transversa.

The Olfactory Lobes.—These develop from the extreme anterior portion of the floor of the hemispheres, as hollow outgrowths, opening into the lateral ventricles in front of the corpora striata. After a short time they become solid. The fold dividing these lobes from the frontal extends backward below the Sylvian fissure to the temporal lobe, defining the olfactory tract.

6. THE CONVOLUTIONS OF THE CEREBRUM (Fig. 514, Nos. 39 to 43; Fig. 515, Nos. 44 to 47; Fig. 516, Nos. 48 to 51).—A clear distinction can be drawn between the *transient* and *permanent* convolutions. The former develop in different degrees in different brains, reach their greatest extent in the fourth month, and disappear early in the fifth month, leaving the cerebral cortex smooth (Mihalkovics).* Their radial arrangement around the central lobe leaves little doubt that they are the mechanical effects of the rapid growth of the mantle around the arrested wall opposite the corpora striata or stem.

The permanent furrows are subdivided into the *primary*, or those which involve a folding of the entire brain-wall, and are visible upon the ventricular surfaces; and *secondary*, or those developed merely as local outgrowths of the cerebral cortex. Following Pansch, the primary furrows, which are naturally the first to appear, may be called *fissures* to distinguish them from the *sulci* or secondary furrows. They arise in the following or-

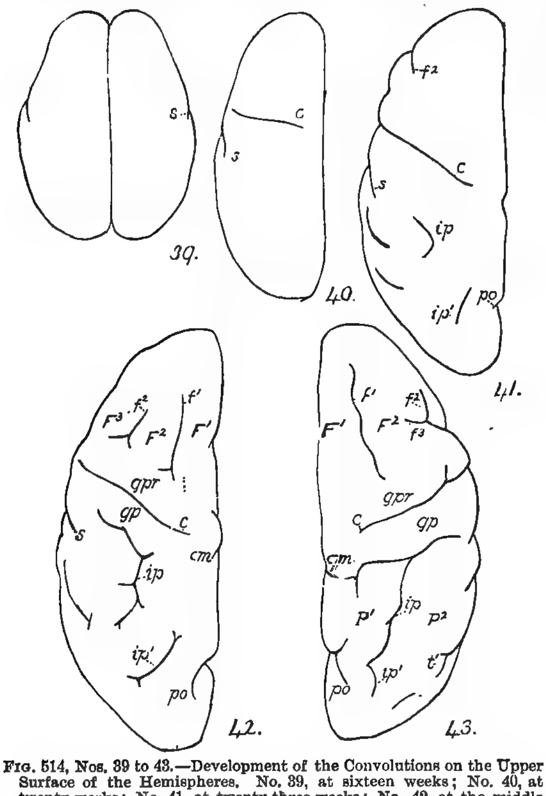


FIG. 514, NOS. 39 to 43.—Development of the Convolutions on the Upper Surface of the Hemispheres. No. 39, at sixteen weeks; No. 40, at twenty weeks; No. 41, at twenty-three weeks; No. 42, at the middle of the seventh month; No. 43, at the close of the seventh month (Ecker.) *c*, Sulcus centralis; *cm*, calloso marginalis; f^1, s. frontalis superior; f^2, s. frontalis inferior; f^3, s. præcentralis; F^1, gyrus frontalis superior; F^2, g. frontalis medialis; F^3, g. frontalis inferior; *gp*, g. postcentralis; *gpr*, g. praecentralis; *ip*, g. intraparietalis; ip^1, g. intrap. posterior; P^1, g. parietalis superior; P^2, g. par. inferior; *po*, s. parieto-occipitalis; *s*, fissura Sylvii.

der: the Sylvian, the hippocampal, the calcarine. (1) The *Sylvian* is not precisely homologous with the other primary fissures, as it results not so much from a fold in the entire hemisphere wall, as from a retardation of surface growth opposite the corpora striata. It appears first as a wide fossa, within which is the central lobe area. As the hemisphere expands, the sides of the fossa are overlapped, so that between the third and fourth months it becomes a cleft. In the fourth and fifth months the Sylvian cleft is narrow but still slightly open. In the sixth month the posterior branch, and in the eighth month the anterior branch closes in; while a month after birth the whole fissure closes completely, covering the central lobe. (2) The *hippocampal* fissure extends, in the eighth month, on the inner surface of the hemispheres from above the septum lucidum to the base of the temporal lobe, arching around the corpora striata, and in its lower extent corresponding to the hippocampus within (Fig. 513, No. 38). Below this fissure is the *gyrus dentatus*, the upper part of which subsequently unites with the opposite gyrus and enters into the formation of the corpus callosum, while its lower arm enters partly into the posterior pillars of the fornix. (3) At the end of the third month appears the important *calcarine* fissure as a backward branch of the hippocampal, and in the fourth month the calcarine branches upward into the *parieto-occipital* fissure.

Division of the Hemispheres into Lobes.—The first steps in this division have already been described. The Sylvian fissure early defines the central and temporal from the superior lobes. In the fourth month the parieto-occipital fissure separates the parietal from the occipital lobes upon the inner aspect of the hemisphere. Toward the end of the fifth, or beginning of the sixth month, appears the sulcus centralis (see below), forming a marked

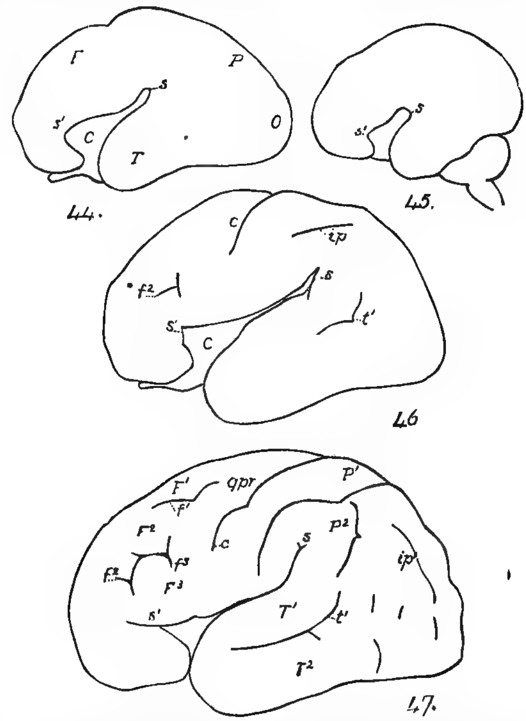


FIG. 515, NOS. 44 to 47.—The Development of the Convolutions on the Sides of the Hemispheres. No. 44, at sixteen weeks; No. 45, at twenty; No. 46, at twenty-three weeks; No. 47, at the close of the seventh month. S^1, anterior branch of the Sylvian fissure; T^1, g. temporalis superior; T^2, g. temporalis inferior; t^1, s. temporalis superior. (Ecker.)

division between the frontal and parietal lobes. In the latter part of the sixth month the parieto-occipital fissure extends to the superior surface of the hemispheres, partially dividing the parietal from the occipital lobes.

The Secondary Gyri and Sulci.—The first to appear is the *sulcus centralis* (fissure of Rolando). According to Wagner this arises as a short transverse furrow in the anterior third of the upper cortical surface, as the frontal lobe, which it defines, is relatively much shorter than subsequently. About the same period (Mihalkovics) the *sulcus calloso-marginalis* arises on the inner aspect of the hemispheres, parallel with the hippocampal fissure, and extending backward from above the genu of the corpus callosum as the upper boundary of the *gyrus fornicatus*.

* This statement is questioned by Wilder.

(2) During the sixth month the following sulci may be observed: The beginning of the sulci *frontalis inferior*, *præcentralis*, and *superior;* upon the parietal lobe, the *intraparietalis*, and upon the occipital lobe, just behind, the *intraparietalis posterior* (the two latter sulci subsequently unite, forming the large intraparietal furrow); upon the temporal lobe appears the *temporalis superior;* upon the under surface of the temporal and occipital lobes appears a trace of the *temporalis inferior*. (3) During the seventh month the sulci described above, many of which are faint surface depressions, deepen and elongate, and the main gyri begin to be well defined. On the frontal lobe the ascending and superior middle and inferior frontal gyri can be made out; the ascending superior supra-marginal gyri are apparent upon the occipital lobe, while the superior temporal and superior occipital, as well as the gyrus fornicatius, are fairly defined. In fact, in the seventh month nearly all the main foldings of the hemispheres come into view, the frontal lobes elongate, the Sylvian fossa narrows to a cleft. The orbital and olfactory sulci sometimes appear as early as this. The sulcus *occipitalis transversus* appears upon the occipital lobe, and the *sulcus olfactorius* in the subfrontal region. Upon the central lobe appear two slight

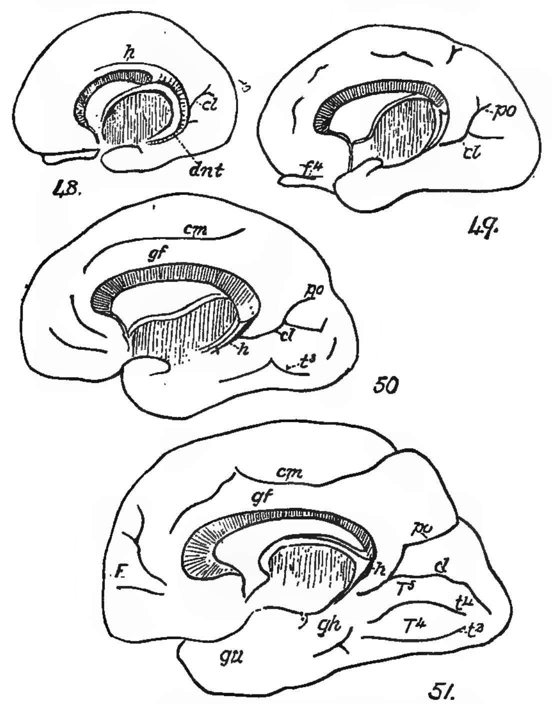


Fig. 516, Nos. 48 to 51.—The Convolutions on the Inner Surfaces of the Hemispheres. No. 48, at sixteen weeks; No. 49, at twenty weeks; No. 50, at twenty-three weeks; No. 51, at the end of the eighth month. *cl*, Fissura calcarina; f^4, s. olfactorius; *gf*, g. fornicatus; *gh*, g. hippocampi; *gu*, g. uncinatus; *h*, s. hippocampi; t^3, s. temporalis inferior; t^4, s. occipito-temporalis inferior; T^4, g. occipito-temporalis lateralis; T^5, g. occipito-temporalis medialis.

furrows; the foremost of these bounds a continuation of the olfactory tract, while the hindmost, the *insulæ primus*, forking above, divides the central lobe into three gyri. (4) In the eighth month the frontal sulci extend forward, but do not quite reach the anterior end of the frontal lobe. Upon the parietal lobe the anterior unites with the posterior intraparietalis, and the gyrus *postcentralis* arises parallel with the præcentralis. Posteriorly, the transverse occipital unites with the intraparietal, and the *occipitalis inferior* completes the threefold division of that lobe. The *temporalis inferior* also appears defining the middle and inferior temporal gyri. The *occipito-temporalis inferior* is one of the last sulci to appear. The ninth month, and the first after birth, are marked by the deepening and extension of the sulci, and by the formation of accessory furrows as branches of the main sulci.

In general, the course of the sulci is in circular disposition around the Sylvian fissure, although the completeness of this order is, of course, broken by the central and præ- and post-central furrows which have a radial disposition. Two of the primary fissures, the Sylvian and hippocampal, are observed to run parallel with the large arteries; whether any causal relationship exists here is doubtful. An adequate theory of convolutional growth has not been arrived at. The following suggestions have been offered: 1. That the convolutions are due to variations in the intensity of growth of the different portions of the cortex, the sulci representing lines of retarded growth, the gyri lines of rapid growth. 2. That the cortex expanding more rapidly than the skull, is crowded into certain folds. This theory has support in the fact that in dolicocephalic skulls there is a tendency to longitudinal folding, and in brachycephalic skulls to transverse folding, but it fails in giving too much of an accidental character to cortical growth. 3. The influence of the brain membranes with their arteries and veins upon the uniformly expanding cortex. 4. The joint operations of the above influences. The probabilities are, from the standpoint of comparative anatomy, that the surface foldings arise, according to laws of growth, within the hemispheres, which have been established with the increasing necessity for more cortical gray substance *pari passu* with the evolution of the higher mental faculties.

III. Histogenesis.

The medullary plate of the encephalic region, like that of the spinal cord, consists at first of several vertical ranges of uniform spindle-shaped cells in radial disposition, with cell processes which continue through the whole thickness of the wall. About the eleventh day, in the rabbit, upon the sides and floor of the external surface of the *medulla oblongata*, there begins the formation of a very delicate layer of unnucleated nerve-fibre processes. Here we meet the important law that *in the brain, as far forward as the cerebral hemispheres, the primitive arrangement of the cell- and nerve-fibre areas is unmistakably the same as in the spinal cord.* In both, the white matter forms a cap upon the ventral and lateral parts, considerably before it extends to the dorsal surface.

Simultaneously, or slightly later than the above, a differentiation similar to that observed in the medulla oblongata occurs in the floor or sides of the mid-brain, and the primitive cerebral peduncles, thus suggested, extend forward in the sides of the infundibulum. Here is met a second law of histogenesis: *the primitive nerve-fibre courses appear first in the posterior encephalic segments, directly continuous with those of the spinal cord, and extend forward.* More in detail the histological changes are as follows:

About the eleventh day, in the hind-brain of the rabbit, there begins a splitting into two layers. Of these the inner-layer cells begin to show a transitional character, while the outer layer metamorphoses into ground substance, scattered cells, and fine fibres. The inner layer then divides into an intermediate layer of blastema and nuclei, and a ventricular layer of cells, which retain their epithelial character. The outer layer then gives off a superficial whitish coat. On section from within outward, at this period, we therefore find the following: (1) derived from the primitive *inner layer*, (*a*) a layer of cells of epithelial character lining the ventricles, and constituting the *ependyma;* (*b*) a thicker layer of transition cells, free nuclei, and protoplasm, which are replaced by the principal cells constituting the mass of the gray substance; (*c*) a layer of fine sheathless nerve-fibre elements, interspersed with a few cells and ground substance, constituting the mass of the white substance; (*d*) last to appear, a superficial, molecular, whitish substance.

It is a disputed question whether the white or gray substance be first formed. In a natural order of development the gray or cell areas would appear first; probably the two processes in any given region are nearly simultaneous; the formation of the pronuclei of ganglion cells

in one layer being step by step with that of the fibre elements in the other. By some authors the fibrils are stated to grow directly from the cell masses. According to Kölliker, however, the fibre substance extends along the base of the mid-brain and sides of the infundibulum, while the inner or gray layer in the hind-brain is still in a transition stage. It should be stated also that the growth of white matter from behind forward, given above as the second law of growth, is not universally accepted.

About the fourteenth day, in the rabbit, the thalami show the primary division into white and gray matter and ependyma, while only the lower and median portions of the hemispheres begin their metamorphoses. The general plan of histogenesis in the fore-brain, primary and secondary, is the same as that behind; but according to Balfour, the early histological distinction between this segment and the mid- and hind-brains is more marked than between the latter and the spinal cord. In the thalami, the conversion of the walls is principally into gray matter lined within by a slender epithelial layer; the white matter, on the other hand, forms the principal element in the sides of the infundibular region. By the sixteenth day, in the rabbit, the cerebral peduncles are well developed, spreading out into the thalami, entering the corpora striata, and by the eighteenth to twentieth day reaching even the lateral walls and roof of the hemispheres. Parallel with the ingrowth of the fibres of the tegmentum, those of the crusta extend into the thalamus and corpus striatum. The fibres of the *tractus opticus* and facial nerve appear early in the more internal portions of the brain-wall. These and other nerve-fibres are originally naked axis cylinders; later they mostly acquire medullary sheaths. Flechsig has observed that there is a parallelism between the original direction of growth of nerve-fibres, and the order of the later acquisition of the medullary sheath. This observation has proved of great assistance in determining the nerve-fibre courses in the brain.

The Cerebral Hemispheres.—On the lateral and dorsal walls of the cerebral hemispheres there is primarily a division into two layers, a superficial thinner layer of rounded cells, and an internal thicker layer of epithelial character. On the sixteenth day we next observe, by a division of the thinner superficial layers, the hemisphere walls dividing into three layers: (*a*) an outer layer, poor in cells; (*b*) a thick intermediate layer, rich in large cells; (*c*) an inner thick layer, poor in cells. Into the latter layer are inserted, first, the spreading fibres of the cerebral peduncles, and later of the corpus callosum; so this inner layer forms the main white substance of the hemispheres and the ependyma lining the ventricles. The intermediate layer (*b*) forms the mass of the gray cortex, while the outer layer (*a*) develops a slender white fibrous covering of the gray cortex, which first appears over the corpora striata. Unlike the posterior segments, we here find the chief mass of white substance inserted between the ependyma and the gray mass, while the lesser mass of white substance enters the thin outer layer. From this time forward, the relative thickness of these layers changes rapidly. The outermost layer becomes much thinner, the gray and white intermediate layers greatly thicken; while the innermost layer is reduced in some cases to a single row of cells.

The Ependyma.—The thinning of the brain-wall, as in the choroid plexuses, is naturally at the expense of the outer layers. It is clear, by reverting to the early stages of development, that the ependyma corresponds to the original outermost epiblast layer. Throughout the changes which occur in the brain-wall, this layer retains its epithelial character and must be classed under nerve-epithelium (Mihalkovics). The cells gradually lose their cylindrical character, becoming more rounded; they send into the brain-wall thread-like processes, and toward the close of fœtal life, they develop cilia upon the ventricular surfaces. The cilia disappear after birth, except in the iter and parts of the fourth ventricle. Upon the choroid plexuses the ependyma cells are flatter, and in the human brain they do not become ciliated.

IV. Comparative Anatomy.

Much light is thrown upon the phenomena of development by the facts of comparative encephalic anatomy. Instead of inserting these facts throughout the descriptive portions of the text, I have collected a few of them here. The brain, as it develops, follows Von Baer's law, that the various embryonic stages approximate the forms of the adult brains of lower animals. Thus it may be said that at the completion of its segmental division the fœtal brain resembles that of the amphibia, especially of such forms as Menobranchus or Menopoma; the resemblance holding good for the general histological as well as the gross structure. At a later period the human brain is like that of the lowest mammals.

The first band-like rudiment of the *cerebellum* closely resembles the adult form of this organ in the amphibia; somewhat later, when the rudiments of the lateral lobes appear, it is in form like that of the birds; one of the last features of low character is the early prominence of the middle lobe, while the lateral lobes are still diminutive, as in the lower mammals, among which the small lateral lobes accompany a rudimentary pons Varolii.

Both the pineal body and hypophysis develop in a somewhat similar manner throughout the entire vertebrate series. In many animals below the mammals the posterior lobe of the *hypophysis* retains its nervous structure. This is an indication that the connective-tissue elements which pervade it in the mammals are due to degeneration. The fact that the anterior lobe is an involution from the roof of the mouth (or from the nasal pit in front of the mouth in the lamprey) has given rise to the conjecture that the hypophysis was primitively either a glandular organ opening into the mouth, or an independent sense organ on the surface of the head between the olfactory organ and the mouth (Scott). The meaning of the *pineal body* is equally interesting and obscure. Evidence is found among the amphibia and fishes that it also passed through the skull originally, and probably reached the top of the head. Goette has accordingly suggested that it is the remnant of a pore leading into the cavity of the brain. Quite recently Rabl-Rückhard and Ahlborn, in view of the manner of growth of the pineal process in the form of a stalk and vesicles (like the optic vesicles), and its position adjacent to the optic thalami and optic lobes, have suggested that it is the rudiment of a median eye.

In some of the fishes, for example, among a few Teleosts, the cerebrum consists of a single unpaired cavity like that of the primary cerebral vesicle. In some cases the division into lateral ventricles is indicated by a gentle fold. This shows that the ventriculus communis is a cavity independent of the third ventricle. Below the mammals the cerebral hemispheres are not united in front of the lamina terminalis by true commissural structures. It is in accord with this fact that the corpus callosum and fornix appear late in embryonic life. The first stage of the *corpus callosum*, as the genu, in the human brain, resembles its adult form in the lowest mammals, the Monotremes. Parallels like the above might be indefinitely multiplied. They show that an intelligent understanding of encephalic structure must be based upon both embryology and comparative anatomy.

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Henry F. Osborn.

BRAIN, DIAGNOSIS OF LOCAL LESIONS IN THE.

History.—Although it was known in the first century that each hemisphere of the brain is in functional relation with the opposite half of the body, the facts upon which the prevailing theory of the localization of different functions in separate parts is based were not discovered until

1822. At that time Thomas Hood, in England, and Bouillaud, in France, noticed that disturbances of speech were caused by disease in the frontal lobes of the brain. M. Dax (1836) was the first to limit the area governing speech to the left frontal lobe, and Broca (1861) located it more exactly in the left third frontal convolution. The discussion of aphasia in the Academy of Medicine in Paris in 1864 awakened general interest and led to further investigation. Until that time scientific men, rejecting the unwarrantable conclusions of Gall and the phrenologists, had believed the teachings of Flourens, that the brain acts as a whole, its various parts not possessing various powers. The pathological evidence against this position collected by Broca, and strengthened during 1864–67 by facts observed by Hughlings Jackson and Meynert, received confirmation in 1870 from a new series of physiological experiments made by Fritsch and Hitzig in Berlin. These investigators found that in animals the anterior portion of the convexity of the brain is motor; that its irritation by electricity causes co-ordinated motions in the limbs of the opposite side, and that its destruction causes paralysis. Ferrier (1873–76), Nothnagel (1877), Munk (1881), and Luciani (1884) have confirmed these results, and have shown further that the posterior portion of the convexity is sensory, its destruction being attended by impairment of the powers of perception through the various senses. Goltz, though opposing a strict limitation of functions to definite regions, admits that the results of destruction of various parts are different, and has noticed that extensive injury to the anterior portion changes the character of an animal from kind to vicious, while injury to the posterior portion has the opposite effect. The conclusions of physiologists differ regarding the results of experiments, but do not overthrow the theory of localization as applied to man. For a mass of pathological evidence has been collected during the past ten years which will bear but one interpretation. Charcot and his pupils in France, Nothnagel, Exner, and Wernicke in Germany, H. Jackson and Ferrier in England, and others, have gathered, classified, and analyzed a very large number of cases of brain disease of limited extent, which were accompanied by definite symptoms, and have established a causal relation between lesions of certain portions of the brain and disturbances of certain functions, both motor and sensory. It has also been discovered that deficient development of an organ is accompanied by deficient development of that part of the brain which is in functional relation with that organ, and *vice versa* (von Gudden).

Further, the researches of Flechsig (1877–84) have proven that an anatomical connection exists between certain organs and certain parts of the brain by means of tracts, which can be distinguished from one another by peculiarities in the time and process of their development. To these same tracts are limited the secondary changes which ensue when the active organ at one extremity of the tract is destroyed.

All these various kinds of evidence combine to establish the conclusion that definite parts of the brain possess distinct functions, and although there remain numerous functions whose location is unknown, and many parts of the brain whose function is undetermined, a sufficient number of facts is available to warrant in many cases of cerebral disease a localization of the lesion.

General Considerations.—Since the different parts of the brain preside over different functions, the symptoms present in any lesion will depend as much upon its situation as upon its nature. Certain general symptoms, such as headache, vertigo, convulsions, coma, or optic neuritis, occur in many forms of disease, and being indications of disturbances of nutrition, or of increased intracranial pressure, do not indicate the position of the disease. Other symptoms, however, such as disturbances of motion, of sensation, of sensory perception, of memory, or of speech, are known as local symptoms, since each is present only when a certain part of the brain is involved. It is from these that the localization of a lesion can be determined. Local symptoms must, however, be interpreted with caution, and the direct effect of the lesion must be distinguished from its indirect effect. For example, immediately after a cerebral hæmorrhage, attended with headache, vertigo, or coma, and possibly general convulsions and vomiting, the local symptoms of hemiplegia, hemianæsthesia, and aphasia may be present, and may lead to the suspicion of a very extensive lesion. After a few days, however, there may remain only a partial hemiplegia, all other symptoms having subsided. In such a case the hemiplegia is the only direct local symptom; the indirect local symptoms—aphasia and hemianæsthesia—being incidental to the pressure on, or to disturbance of, circulation in parts adjacent to the actual seat of disease. It is only when a lesion is single, its effects stationary and of some duration that a diagnosis of its position is to be made.

In diagnosticating the position of a lesion it is necessary to distinguish disease in the cortex from disease within the hemisphere. The functions of these parts are different. The gray cortex receives and initiates impulses. The white matter within the hemisphere transmits the impulses. The impulses sent along white tracts to the cortex become conscious perceptions only when they reach their destination in the gray matter. The impulses passing along the white tracts from the cortex have been started in the gray matter as conscious volitions by effort. Thus sensation or motion may be suspended either by disease in the cortex or by disease in the tracts within the hemisphere. The cortex has another function. A sensation once perceived, or a motion once acquired, leaves behind it a trace, whose nature is unknown, which shows itself in a disposition in the cells of the cortex to react more promptly to a similar impulse than to a dissimilar one. This is the physical basis of memory. Since similar impulses always enter by the same sensory organ, and since each organ is connected with its own region of the cortex, it follows that the various memories are distributed in various regions. But these memories are often associated in consciousness, and this association is secured by means of white fibres which pass between and connect the various regions. It becomes evident, therefore, that diseases of memory may afford an important clue to the location of a lesion; and that the distinction between a disease of the gray cortex involving a loss of a certain kind of memory, and one of the white tracts within the hemisphere interfering with the proper association of ideas must not be overlooked. No part of the gray matter can act vicariously for another part. Each tract conveys its own impulses.

Diagnosis.—I. *Cortex Cerebri.*—1. Lesions involving the frontal lobes upon the base may destroy the olfactory bulb or tract and produce anosmia on the side of the lesion. Lesions in the other convolutions of the frontal lobes, excepting those in the posterior part of the third convolution of the left side, present no distinctive local symptoms. Some disturbance of mental action, manifested by an inability to concentrate the attention, to think connectedly, and to control the emotions, or even by a condition of imbecility, may be caused by disease in this region. These convolutions are often defective in idiots, and their comparative development in animals determines the mental power of the individual. But disease in this region in man does not cause a loss of any particular mental faculty, and for the higher powers of mind no location can be determined. Normal mental action implies the integrity of the entire brain. When general symptoms of cerebral disease are present, but no local symptoms can be found, the possibility of disease in the frontal convolutions is to be considered, and the occurrence of the mental disturbance mentioned affords a presumption in favor of this location.

Lesions in the posterior part of the third frontal convolution on the left side in right-handed, and on the right side in left-handed persons give rise to ataxic or motor aphasia (Fig. 517, 1). In this area are located the memories of the combination of motor acts necessary to the pronunciation of words, memories which have been acquired by practice. If these memories are blotted out, the ability to initiate the impulse required to produce a given sound is lost, and speechlessness results. When this convolu-

tion alone is affected the patient can understand what is said to him, and may be able to write, but cannot talk (see Aphasia).

2. Lesions of the anterior and posterior central convolutions and of the paracentral lobule produce disturbances of motion (Fig. 517, 2 to 4). The motor tracts which connect these convolutions of each hemisphere with the body decussate partially in the medulla, and the degree of the decussation differs in different individuals. In the large majority of persons the tracts which cross to the opposite side are so much larger than those which go to the same side, that the symptoms of cerebral disease are only noticed on the side of the body opposite to the seat of the lesion. In all cases, however, except in those in which the decussation is complete (one in sixty), the side which is apparently normal is slightly affected. The disturbances of motion may be in the form of spasms and convulsions, or in the form of paralysis. Lesions irritating the motor region give rise to the former; those which destroy the cortex to the latter. The lower third of the anterior central convolution is in functional relation with the muscles of the face and tongue (Fig. 517, 2). The middle third of both central convolutions governs the arm (Fig. 517, 3). The upper portion of both convolutions and the paracentral lobules contain the motor centres for the body and leg. The area related to the movement of the eyes is located by Landouzy and Exner in the inferior parietal lobule. A more exact localization of motor centres, such as for the flexor or extensor muscles of a limb, is not yet justified from pathological data. As

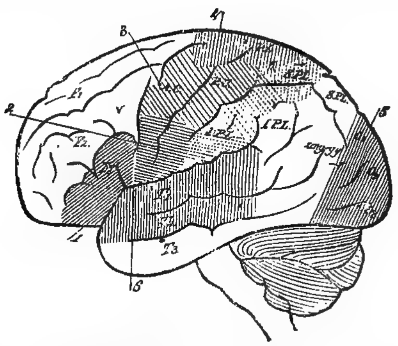

FIG. 517.—Convolutions of the Brain. (After Ecker.) *F.*, frontal; *T.*, temporal; *O.*, occipital; *ang. gy.*, angular gyrus; *A. C.*, ant. central; *P. C.*, post. central: *P. L.*, paracentral lobule; *S. P. L.*, superior parietal lobule; *I. P. L.*, inferior parietal lobule; 1, area of speech, motor; 2, sensori-motor area for face; 3, sensori-motor area for arm; 4, sensori-motor area for leg; 5, visual area; 6, auditory area, area of speech, sensory.

these areas for each part are distinct, cortical lesions of limited extent may affect one alone, or two adjacent areas; but it is only lesions of very great extent which can destroy them all. Monospasms, or monoplegia, are, therefore, prominent symptoms in disease of the motor region. An irritation beginning in one area may extend to adjacent areas, in which case a convulsion may commence in one part and then involve other parts. The relative position of the areas, then, determines the order of progress of the convulsion, face, arm, and leg being successively affected, or *vice versa;* and face and leg never being involved together without affection of the arm. When the entire side is involved the convulsion may become general. The seat of the initial irritation may, therefore, be indicated by the order in which the spasms extend. After such a spasm there remains a paresis in the muscles affected, those last and least involved recovering first (see Epilepsy). If the irritating lesion becomes a destroying lesion the monospasm is succeeded by monoplegia, and from the part of the body affected the area in the motor region which is destroyed can be determined. In cortical disease it is seldom that the lesion involves a single area without encroaching upon adjacent areas; hence, associated monoplegia of face and arm, or arm and leg, are more frequently met with than paralysis of one part alone. But even in these cases the disturbance of motion usually begins or is more marked in one part, rather than in both equally, and the order of extent of paralysis may indicate the direction in which the disease is progressing, and the place from which it started.

In paralysis from cortical lesion there is a loss or marked impairment of the muscular sense, and there may be some disturbance of general sensation. A loss of motor memories, *e.g.*, the motions involved in writing, playing an instrument, using a tool, occurs in cortical disease, and may indicate that the seat of the lesion is in the area of the arm. The limits of the region receiving impulses which awaken the perception of touch, temperature, and pain are not fully determined. It is known, however, that the motor and sensory regions coincide, while it is probable that the sensory region extends beyond the motor and includes the parietal lobules which lie posterior to the motor area (Fig. 517, dotted lines 2 to 4). Lesions affecting the posterior central convolution give rise to combined motor and sensory symptoms, the sensory areas lying in the same order as the motor areas, face, arm, and leg in the lower, middle, and upper thirds respectively. Lesions in the motor area anterior to the fissure of Rolando usually produce paralysis without anæsthesia. Lesions in the parietal lobules may produce anæsthesia but do not cause paralysis.

Each sensory area is in functional relation with the opposite limb to a much greater degree than with the limb of the same side. Mono-anæsthesia may, therefore, occur from cortical lesion. The loss of sensation is rarely total, as it is probable that the decussation of sensory impulses is rarely complete. The degree of impairment of sensation is only to be ascertained by comparison of the affected limb with the other three. If the sensory area is not destroyed but is only irritated, subjective sensations in the limb whose area is affected occur, and such mono-paræsthesiæ are valuable indications of cortical lesion, when disease in other parts is excluded.

Monospasm and monoplegia, mono-paræsthesiæ or mono-anæsthesia, are, therefore, the chief symptoms of cortical disease in the sensori-motor area. The two former indicate an affection lying anterior to the parietal lobules. The two latter may occur when these also are involved. No other local symptoms of disease in the parietal lobules are known, the disturbances of speech or of sight occurring occasionally when the supra-marginal gyrus is involved being due to a coincident lesion of the tracts passing beneath it.

3. Lesions of the three occipital convolutions and of the cuneus produce disturbances of vision (Fig. 518, 5). Each occipital lobe is in anatomical connection with the like-named half of each retina, and hence a lesion of one occipital lobe produces an affection of vision in the opposite half of both visual fields. Irritation of the cortex of this region may cause hallucinations of vision, and if the irritation is in one lobe the subjective sights will appear upon the opposite side of the median line, and will move with the eyes of the patient. Destruction of the cortex will produce bilateral homonymous hemianopsia, *i.e.*, blindness in the opposite half of both eyes, and may also cause a loss of visual memories; the patient will fail to recognize familiar objects, and cannot recall scenes and faces formerly known. If the lesion is in the left occipital lobe, written and printed language also may no longer be recognized, and the patient, therefore, may lose the power of reading while speech remains. It is not yet possible to affirm the functional relation between various parts of the visual area in the occipital convolutions and various parts of the retinal surfaces, although a few cases indicate that such a relation may exist. The relation of the angular gyrus, which lies anterior to the occipital lobe, to vision is undetermined. While it was formerly supposed to be the centre of the visual area by Ferrier, this view has been opposed by German authorities, who hold that the disturbances of vision which have occurred occasionally when it was diseased have been due to a lesion of the visual tract which lies beneath it and which passes to the occipital lobe.

4. Lesions of the first and second temporal convolutions produce disturbances of hearing, but whether each lobe is related to the opposite ear alone, or to both ears, is undetermined (Fig. 518, 9). Irritation of these convolutions may cause hallucinations of hearing, and destruction of them may cause deafness. If the lesion is upon the left side and involves the first convolution, the symptom produced is word-deafness, or loss of memory of the sound of words, with consequent inability to recognize the meaning of spoken language or to recall the words necessary to speech. This is also known as sensory or amnesic aphasia. It can be distinguished from motor or ataxic aphasia by the inability of the patient to understand what is said to him (see Aphasia).

5. Lesions at the apex of the temporo-sphenoidal lobe may produce disturbances of taste and smell, but further investigations are needed to establish the localization of these functions.

6. Lesions of the island of Reil have caused disturbance of motion in the face and arm of the opposite side, and also have caused aphasia when the left island was involved. It is not certain, however, to what extent these symptoms were dependent upon the affection of adjacent convolutions, of tracts beneath the island, or of the basal ganglia (Figs. 519 and 520). The associating tract which joins the sensory with the motor speech-centres lies just under the convolutions of the island of Reil and de-

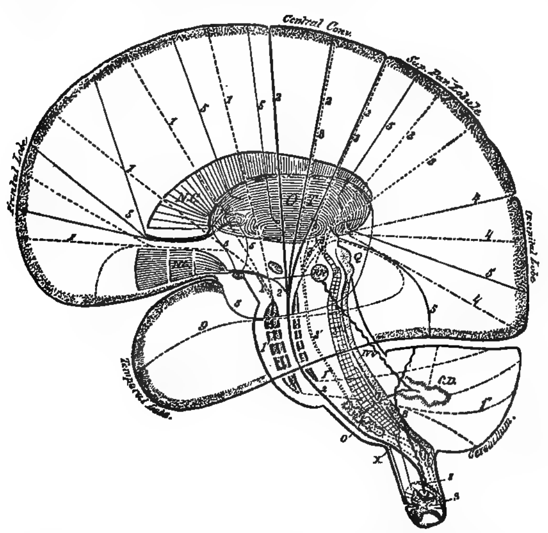

FIG. 518.—Cerebral Tracts. (Modified from Flechsig's Plan.) *N. C.*, nucleus caudatus; *N. L.*, nucleus lenticularis; *O. T.*, optic thalamus; *Q.*, corp. quadrigemina; *R. N.*, red nucleus of the tegmentum; *IV. v.*, fourth ventricle; *C. D.*, corp. dentatum of cerebellum; *O.*, olive; *X.*, motor decussation. The lines represent the tracts in the internal capsule; 1, tracts from frontal lobe to pons and cerebellum; 2, tracts from motor area to cord and motor tracts; 3. tracts from cord to sensori-motor area, sensory tracts; 3′, tract of muscular sense in medulla, pons, and crus, the lemniscus; 3″, tract of other sensations in medulla, pons, and crus, the formatio reticularis; 4, tract from thalamus to occipital lobe, visual tract; 5, radiations from thalamus to all parts of cortex; 7, tract from olive to opposite cerebellar hemisphere; 8, direct cerebellar tract from cord to vermiform lobe; 9, auditory tract (?).

struction of this tract would cause paraphasia. Lesions of the island of Reil would be especially liable to affect the circulation in the motor area, since the branches of the middle cerebral arteries pass over it. While, therefore, it can be stated that hemiplegia and aphasia may be produced by lesions here, it is probable that they would be indirect and not direct local symptoms. The function of the island of Reil is unknown.

The facts which have been stated regarding cortical lesions are based upon autopsies and are independent of any physiological considerations regarding the functions of the various parts, although they agree with the results of experiment on animals. It is evident that disease which affects an extensive region of the cortex may produce a number of symptoms arising from the implication of several areas at the same time. Such wide-spread disease is usually attended by general symptoms, marked mental disturbance, loss of memory, and lack of self-control, as well as by the local symptoms.

II. *Cerebral Tracts.*—1. The white matter of the brain consists of fibres of two varieties, association fibres which join the different convolutions and functional regions with each other, and projection fibres which join the different convolutions with the basal ganglia and with the gray matter of the pons, medulla oblongata, and spinal cord. These fibres are so interlaced in the centrum ovale that neither can be injured without affecting the other. An interference with the passage of impulses through association fibres produces symptoms of a mental character. An example of this has been cited in describing lesions of the island of Reil, viz., paraphasia. The patient suffering from this disease can recall the desired words, and is able to initiate the motions necessary to speech, but the associating tract between the memory of

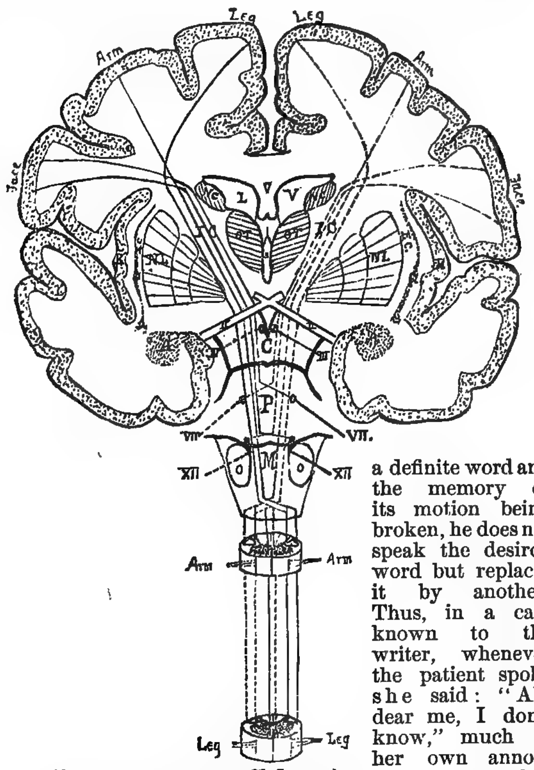

FIG. 519.—The Motor Tract. *N. L.*, nucleus lenticularis; *N. C.*, nucleus caudatus; *O. T.*, optic thalamus *L. V.*, lateral ventricles; 3, third ventricle; *P.*, pons. *M.*, medulla; *R.*, island of Reil; *A.*, amygdala; *E. C.*, ext. capsule; *I. C.*, int. capsule; *Cl.*, claustrum; *C.*, crura; *O.*, olivary body.

a definite word and the memory of its motion being broken, he does not speak the desired word but replaces it by another. Thus, in a case known to the writer, whenever the patient spoke she said: "Ah, dear me, I don't know," much to her own annoyance, as she understood what was said to her and knew what she ought to say in reply. The forms of paraphasia are numerous, but are all to be referred to lesion of association fibres. It is very probable that many defects of memory, and much of the apparent stupidity in brain diseases is to be ascribed to a failure of function in these fibres by which ideas are associated. Nothing more definite can be stated regarding their injury, and the mental symptoms, aside from paraphasia, do not indicate the location of the disease.

2. Lesions of projection fibres produce well-marked local symptoms. It is by means of these fibres that all parts of the body are joined to connecting parts of the brain, so that in imagination a map of the body can be projected upon the cortex of the brain. An interference with any separate bundle of fibres will therefore produce symptoms in the organ with which it is joined, and therefore will cause somewhat similar effects to those produced by a lesion of the corresponding part of the cortex.

It is necessary to consider the lesions of the various tracts, as they produce different symptoms. The projection fibres passing inward and downward from the extensive cortical surface of each hemisphere converge, and are finally collected, into a compact tract which lies between the basal ganglia and is known as the internal capsule. Many fibres pass into the basal ganglia, but as their function is only conjectured, the effect of their destruction is unknown. Others pass between the ganglia, through the capsule, and issuing from its basal portion enter the crus cerebri, and traversing it go down to the pons, medulla, and cord.

Since the fibres passing through the capsule are gathered from distant and widely separated regions of the cortex, a small focus of disease in the capsule may produce as serious and wide-spread symptoms as disease of great extent in the cortex. Extensive disease in the cortex, or centrum ovale, produces considerable mental impairment, but this is not true of capsular disease. Hence in any case in which the symptoms are extensive, but the mind unimpaired, the probability is in favor of a small lesion in the brain tracts rather than of a large lesion in the cortex. The brain tracts in the capsule may be injured either directly, by lesions in their course, or indirectly, by lesions in the basal ganglia in whose vicinity they pass. In both cases the initial symptoms will be the same if the disease begins suddenly, but in the latter case recovery may follow, while in the former the symptoms may increase in number, owing to secondary degenerations following a lesion of a tract. If the disease is a slowly progressive one (*e. g.*, tumor), general symptoms may precede local symptoms, and indirect local symptoms will be succeeded by direct local symptoms.

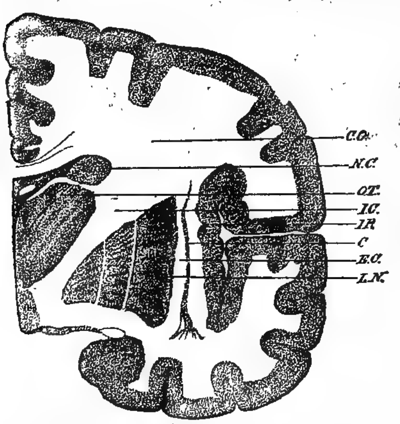

FIG. 520.—Frontal Section through the Brain at the Post. Central Convolution. *C. O.*, centrum ovale; *N. C.*, nucleus caudatus; *O. T.*, optic thalamus; *I. C.*, internal capsule; *I. R.*, island of Reil; *C.*, claustrum; *E. C.*, external capsule; *L. N.*, lenticular nucleus.

The internal capsule is divided into two halves, an anterior and a posterior division, by the projection of the apex of the lenticular nucleus, which lies on its outer side. Through the anterior division pass the projection fibres from the frontal lobes (Fig. 518), and the fibres which join the anterior parts of the cortex with the basal ganglia. Nothing is known as to the exact function of either of these bundles of fibres, and no symptoms of their injury can be stated. Extensive lesions may occur in the white matter of the frontal lobes, affecting both association and projection tracts without producing any symptoms, although in many such cases the symptoms present in cortical lesions of the frontal lobes do occur. Through the posterior division of the internal capsule pass several important tracts. These are (1) the motor tract from the lower third of the central convolutions, which curves over the lenticular nucleus and passes down in the anterior part of the posterior division of the capsule, enters the second quarter of the crus, thence passes into the median part of the ventral half of the pons, and turning downward ends in the facial and hypoglossal nuclei (Fig. 521, *Fa.*); (2) the motor tract from the other thirds of the central region (Fig. 518, 2), which is known as the pyramidal tract, since its fibres after passing through the third quarter of the crus and the ventral portion of the pons, make up the pyramid of the medulla (Fig. 521, *M.*); (3) the tract conveying general sensations from the entire body (Figs. 518, 519), which lies just behind the pyramidal tract, and having come from the tegmentum of the crus, and passed through the posterior third of the capsule, radiates toward the parietal convolutions (Fig. 521, *S.*); (4) the visual tract (Fig. 518, 4), whose fibres, issuing from the pulvinar of the thalamus, pass upward and turn backward in the capsule on their way to the occipital lobe (Fig. 521, *O.*); (5) the auditory tract, which passes through the lower posterior segment of the capsule on its way from the auditory nucleus to the temporal lobe (Fig. 518, 9). Lesions of the internal capsule which affect one or more of these tracts cause distinct local symptoms. Lesions in the motor tract produce paralysis, whose distribution will depend upon the extent to which the tract is involved. Usually the entire tract is affected and hemiplegia results; but occasionally the facial and hypoglossal muscles are only slightly affected. In all cases the upper branch of either facial nerve escapes, since its cortical centres are bilateral. In lesions of the pyramidal tract the arm and leg of the opposite side are always paralyzed together. Lesions lying in the sensory tract cause hemianæsthesia, which is rarely absolute, but usually in the form of great impairment of sensation on the opposite side from the lesion. Lesions lying still further back may affect the visual tract and cause blindness in the opposite half of both eyes. It is possible that lesions in the lower part of the capsule may produce loss of hearing in the opposite ear. Whether taste and smell are ever affected by capsule lesions is undetermined.

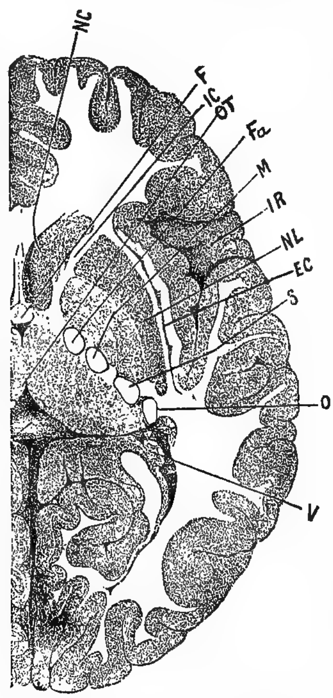

FIG. 521.—Horizontal Section through the Brain. (After Strümpell.) *N. C.*, nucleus caudatus; *F.*, fornix; *I. C.*, ant. half of internal capsule; *O T.*, optic thalamus; *Fa.*, facial tract; *M.*, motor tract; *S.*, sensory tract; *O.*, visual tract, in post. half of internal capsule; *I. R.*, island of Reil; *N. L.*, nucleus lenticularis; *E. C.*, external capsule; *V.*, lateral ventricle, post. cornu.

It is evident that an extensive lesion in the capsule may involve two or more of these tracts; and hemiplegia, with hemianæsthesia and hemianopsia, could not be produced by a single lesion lying in any other part. The initial effects of a hæmorrhage or thrombosis, which involves the internal capsule, may be extensive, as several tracts may be affected. If but one, however, is really destroyed, the affection of the others will be temporary, and the symptoms will decrease in extent and severity until they are limited to the affected tract. It is only after the temporary effects have subsided that the disease can be located accurately. On the other hand, a slowly progressing lesion, tumor, or abscess, may involve one tract after another in succession, and the progress of the case will determine the localization of the lesion.

3. Aphasia may be due to a lesion in the tract which joins the third frontal convolution with the facial and hypoglossal nuclei in the pons. Two courses have been described as taken by this tract. One corresponds to the course of the fibres from the face area of the motor region through the internal capsule, already detailed. The other is as follows: The aphasic tract passes inward from the

frontal region, turns backward, crossing at right angles the motor tract, and going along the upper border of the lenticular nucleus, in the external capsule, to its posterior limit, it curves over the nucleus and enters the internal capsule near the sensory tract, then crosses this tract to the second quarter of the crus, and so reaches the pons. Lesions in the course of either of these tracts have produced aphasia when in the left hemisphere. Such an aphasia resembles ataxic or motor aphasia, and is not to be distinguished from it. It is more liable to be associated with agraphia than when the lesion is in the frontal convolution, as association fibres are likely to be destroyed when the lesion is in the centrum ovale.

4. Having considered lesions of the cortex, and of the tracts as they are collected in the capsule, it is evident that lesions of the centrum ovale, through which the tracts pass on their way from one to the other, will produce similar effects to those in either part, according as it lies nearer one or the other (Fig. 519, *C.*, *O.*). Lesions of the centrum ovale have no distinctive symptoms by which they can be differentiated from lesions in the cortex or capsule, unless the affection of association fibres as well as of projection fibres adds distinct mental symptoms. If the lesion is so situated as not to affect any of the projection tracts it will not produce any local symptoms.

III. *Lesions of the basal ganglia* are very frequent and give rise to many symptoms. These symptoms are, however, to be ascribed to a coincident affection of the tracts just mentioned, which pass through the internal capsule between the ganglia (Figs. 520 and 521), and hence the local symptoms of lesions in the lenticular or caudate nucleus and optic thalamus are those of lesions of the internal capsule opposite those bodies, viz., in its posterior division. If the symptoms are permanent, the capsule is probably injured. If the symptoms pass away, the capsule was incidentally affected. And the effects of the lesion may entirely subside while the lesion remains, if it is limited to either of these ganglia. It is, therefore, evident that we cannot locate a lesion in the ganglia from any direct local symptoms; for, as we are ignorant of the function of the ganglia, we do not know what is the effect of their destruction. The hemichorea and hemiathetosis which remain occasionally after lesions of the thalamus, are to be regarded as symptoms of irritation constantly exerted upon the motor tract passing near it. There are few facts to support the assertions that the optic thalamus is a sensory ganglion, except that lesions of the pulvinar cause hemianopsia. The basal ganglia, doubtless, have important reflex functions, and comparative anatomy indicates that some functional relation exists between the lenticular nucleus and the arm; between the caudate nucleus and the leg; between the thalamus and the organs of sensation. The effects of a lesion limited to any one of these ganglia, and producing no influence upon adjacent parts is, however, beyond detection. As a matter of fact seventy per cent. of the cases of hemiplegia are due to a lesion in the basal ganglia and affecting the internal capsule; and from the symptoms and nature of the disease its location there can usually be affirmed. The diagnosis is, however, made from the capsular symptoms, as already detailed.

IV. *Lesions of the external capsule and of the claustrum* cannot yet be located (Figs. 520 and 521). If on the left side, they usually produce paraphasia like the lesions of the island of Reil.

V. *Lesions of the corpora quadrigemina* are very rare. If the anterior pair is involved, blindness, loss of pupil reflex, strabismus, and nystagmus may be produced. If the posterior pair is involved disturbances of co-ordination may be marked. As both pairs are usually affected together, the combination of these symptoms may aid a diagnosis. Blindness is such a common symptom of cerebral disease that it is only when it is not due to choked disk, optic atrophy, or neuritis, and when it is not of the nature of hemianopsia, that it is to be thought a local symptom of quadrigeminal lesion. A defective action of the same branches of the oculo-motor nerves on both sides is rather more characteristic of quadrigeminal disease than the total affection of one nerve. Cases are yet too few to warrant more accurate statements.

VI. *Lesions of the tegmentum of the crura cerebri*, which lies beneath the corpora quadrigemina, have not been recorded. Since the sensory tracts pass through this region, anæsthesia might be produced by such a lesion, and the proximity of the corpora quadrigemina would give rise to indirect local symptoms of their affection. Lesions of the red nucleus are supposed to cause the symptom of inco-ordination which occurs when the posterior pair of the corpora quadrigemina are involved. They also cause paralysis of the third nerve, which passes through this nucleus. Lesions of the foot of the crus cerebri, in which the motor tract passes, cause hemiplegia of the opposite side. As the third nerve issues through the foot of the crus, a lesion here causes a paralysis of this nerve on the side of the lesion. Hence hemiplegia of one side, with third-nerve paralysis of the other side, indicates a lesion of the foot of the crus cerebri on the side of the third-nerve paralysis. Lesions on the base which press upon this part will produce the same combination of symptoms.

VII. *Lesions of the cerebellum*, if located in the hemispheres and not in the median or vermiform lobe, and if of such a nature as not to exert pressure on surrounding parts, may not produce any symptoms. If the lesion is in the vermiform lobe, disturbances of co-ordination occur known as cerebellar ataxia, and consisting in an inability to walk without staggering like a drunken man. The ataxia only exists while the patient is in an upright position; it rarely affects the motions of the arms, and when it does it never interferes with the fine adjustments, but only with extensive movements in space, *e.g.*, grasping objects at a distance. These patients can stand with eyes closed without swaying. In these respects the ataxia differs from that of posterior sclerosis. A second characteristic symptom of cerebellar disease located in the vermiform lobe is vertigo. This may be very severe, but as it may occur without ataxia, and ataxia may be present without vertigo (though rarely), the two are not to be considered as interdependent. Vertigo is increased by rising to an erect position, but may persist when the patient is in bed. It decreases somewhat when the patient has remained fixed in any position for some time; but is always increased when he closes his eyes. The vertigo is usually an early symptom of cerebellar disease. It is more constant and persistent in cases in which the intracranial pressure is increased. It may gradually pass off in other cases. Cerebellar vertigo does not differ from vertigo in Ménière's disease, and is probably due to an affection of the terminal fibres of the eighth nerve, from the semilunar canals or their nuclei. The vertigo of Ménière's disease is, however, usually accompanied by deafness. Ataxia and vertigo together afford strong presumption of disease in the vermiform lobe, although neither alone is sufficient for a diagnosis.

The indirect local symptoms of cerebellar disease may be numerous. They are due to an affection of the tracts and nerve nuclei in the pons and medulla (see Fig. 518). Various forms of paralysis and anæsthesia, vaso-motor disturbances, obstinate vomiting of a projectile character, general symptoms of intracranial disease, *e.g.*, headache, optic neuritis, are usually present with tumors, abscesses, or hæmorrhages in the cerebellum, especially if they are in the median lobe. The combination of cerebellar ataxia and vertigo with these and other symptoms of pons disease (see Pons) affords clear evidence of disease in the cerebellum.

Lesions of the cerebellum have no apparent effect upon the mental powers when they occur in adults. A deficient development of the cerebellum is, however, a frequent cause of congenital idiocy. When one cerebellar hemisphere fails to develop, the opposite olivary body in the medulla and the opposite hemisphere of the cerebrum usually present an atrophic appearance.

Lesions of the middle peduncles of the cerebellum, the crura cerebelli ad pontem, produce characteristic symptoms. These consist in a tendency on the part of the patient to assume a forced position, to turn toward or fall

toward one side in walking, or even to revolve constantly about one axis of his body. The forced movements may be made by the eyes (conjugate deviation in one direction), by the head, or by the entire body. In a case seen by the writer, in which the autopsy showed a tubercular tumor in the left middle peduncle and in the vermiform lobe, in addition to ataxia, vertigo, vomiting, and headache, the patient lay constantly on his left side, and when he turned upon his back, or toward the right side the vertigo became so excessive that he was obliged to resume at once his former position. In walking, this patient showed a tendency to fall toward the right side, and found it impossible to turn around toward the right. Such patients may lose their balance in moving in one direction, *e.g.*, forward or backward, and in attempting to regain it may be obliged to hasten their movements. This has been interpreted wrongly as a tendency to compulsory walking in one direction, *e.g.*, backward. It is really due to the vertigo. Lesions of the other peduncles of the cerebellum do not produce any known characteristic symptoms aside from those of cerebellar disease.

VIII. *Lesions upon the base of the brain*, tumors, chronic meningitis, may produce local symptoms by affecting the parts lying near them. Thus all the cranial nerves may be involved either separately or in various combinations, and the nerve first or most severely affected may indicate where the lesion began. If such a lesion affects the optic nerve of one side, the optic chiasm, or the optic tract, blindness, either in the form of amaurosis of one eye, or hemianopsia of some variety will be produced. If the lesion affects the crus cerebri or pons, the symptoms of lesion of this part (*vide supra* and Pons) may be present in addition to cranial nerve paralysis. In all cases progressive bulbar paralysis is to be excluded before the diagnosis is made. The local symptoms of lesion of those parts of the cortex which lie on the base of the skull are undetermined, but a tumor of some extent which invades the left Sylvian region may cause aphasia from pressure upon the island of Reil. The variety of symptoms possible in basal disease can be determined by the study of the organs upon the base of the brain (see Anatomy), and any unusual combination of symptoms in intracranial diseases, especially if of syphilitic origin, should lead to a question as to the possibility of a lesion in this locality.

M. Allen Starr.

BRAIN: EMBOLISM AND THROMBOSIS. EMBOLISM. —*Etiology.*—Cerebral embolism is almost always the result of an endocarditis, either acute or chronic, of the left side of the heart. In acute ulcerative endocarditis the emboli are usually very small, and lodge in the capillaries. This form of the disease will not be discussed in this article.

The embolus consists generally of small, soft particles of fibrin which have been detached by the current of blood from the vegetations on the valves of the heart. But the embolus may also be composed of calcified particles, or of pieces of the valves which have been separated by the ulcerative process from the main part of the valve. Less frequently the embolus is detached from a cardiac thrombus, situated often in the left auricular appendix, or near the apex of the left ventricle.

In rare instances the embolus is derived from the right side of the heart, and such cases have been explained either by the patency of the foramen ovale, or by the transmission of the embolus through one of the pulmonary veins, which are said to constitute a direct communication between the right and left sides of the heart. Cohnheim reports a case of embolism of the middle cerebral artery, owing to thrombosis of the veins of the lower limb. In this case the foramen ovale readily admitted three fingers. So far as we are acquainted with the literature of the subject, this is the only case of the kind on record.

Myocarditis may also give rise, though very rarely, to cerebral embolism by causing rupture of the endocardium, and the consequent admixture of the products of inflammation with the blood. This is also true of gummatous or other growths in the substance of the heart, which proliferate through the endocardium.

Another source of embolism is found in atheromatous degeneration and calcification of the inner coats of the aorta, with subsequent deposit of fibrin, and in aneurism of the same vessel. Embolism may result also from thrombosis of one of the arteries in the circle of Willis, a portion of the thrombus becoming detached and giving rise to an embolus in one of the more peripheral vessels in the brain.

Cerebral embolism may also result from gangrenous or other processes in the lungs, which have caused ulceration and finally perforation of a vein, and thus permit the entrance of the gangrenous or other material into the blood. This mode of development has been referred to previously in the discussion of abscess of the brain.

Tumors may give rise to embolism in the same way. Another equally rare cause of embolism is the result of wounds, phlegmonous inflammations involving the subcutaneous adipose tissue, and complicated fractures of the bones in which inflammatory processes are set up in the medulla of those organs.

Von Dusch maintains that many of the cases of sudden death in pleurisy during aspiration, or while the pleura is being washed out, are due to the formation of thrombi in the pulmonary veins. He believes that the development of paralysis, which is observed sometimes under such circumstances, may be explained by the secondary occurrence of cerebral embolism. Indeed, in one instance of this kind, the cerebral emboli were discovered at the post-mortem examination. Finally, mention should be made of the capillary pigment emboli of the brain, seen occasionally in severe forms of intermittent and remittent fever. These may be so numerous as to give the brain a chocolate color. All the cases of the kind which have come under our observation have originated in Central or South America.

Cerebral embolism occurs much more frequently in males than in females, probably because the former are more liable to attacks of acute articular rheumatism. It occurs most frequently in early manhood and middle life, and is extremely rare in childhood, although cardiac disease due to rheumatism is not by any means so infrequent at this age as is generally believed.

Pathological Anatomy.—Cerebral emboli (with the exception of the capillary emboli, which will not be discussed in this article) are usually single, and, in the majority of cases, are situated in the left middle cerebral artery. This predilection is explained by the fact that the current of blood from the aorta passes by a straighter line into the left carotid than into the right carotid, and that, furthermore, the left middle cerebral artery is the direct continuation of the carotid. It has been claimed by Gelpke, on the basis of statistics, that the left middle cerebral presents only a slight preponderance over the right middle cerebral in this respect, but this is probably owing to the fact that, on account of the usual situation of the embolus in the vessel on the left side of the brain, the history of such cases is not generally reported.

In a certain proportion of cases the emboli are situated in other vessels, and even two or more may be present at the same time.

If the embolus is situated in one of the arteries of the circle of Willis, no secondary lesion of the brain-tissues is produced, as the free collateral circulation at once compensates for the obstruction to the current of blood which has been produced by the plug. The effect produced by embolism of other cerebral arteries varies according to the character of the vessel, whether it is a terminal artery or not.

The following is a brief *résumé*, according to Duret, of the distribution of the blood-vessels to the brain. These vessels may be divided into two classes: First, those which are given off at the base of the brain and at once enter the organ to supply the parts situated above (basal ganglia, etc.); and secondly, the continuations of these vessels which supply the cortex. We shall first describe the former.

The anterior cerebral and anterior communicating arteries send off a number of small branches which supply the anterior part of the corpus striatum.

The posterior cerebral artery sends branches to the walls of the third ventricle, the optic thalamus (mainly the posterior portion), the tegmentum of the crus cerebri, and the corpora quadrigemina.

The middle cerebral artery (the most important artery of the brain) gives off a number of branches before it supplies the cortex: 1, The internal striate arteries to the first and second divisions of the lenticular nucleus and the internal or white capsule; 2, the lenticulo-striate arteries which supply the anterior part of the third division of the lenticular nucleus, of the internal capsule, and also pass to the corpus striatum; 3, the lenticulo-optic arteries which pass to the posterior part of the third division of the lenticular nucleus and the anterior portion of the optic thalamus.

The following is the cortical distribution of these vessels. The anterior cerebral artery supplies the convolutions on the inferior surface of the frontal lobe, the first and second frontal convolutions, the paracentral lobule, and the præcuneus.

The posterior cerebral artery supplies the gyrus uncinatus and hippocampus, the inferior surface of the temporo-sphenoidal lobe, and the occipital convolutions.

The middle cerebral breaks up into five branches: 1, To the third frontal (Broca's) convolution; 2, to the ascending frontal convolution; 3, to the ascending parietal convolution; 4, to the inferior parietal and superior temporo-sphenoidal convolutions; 5, to the first and second temporo-sphenoidal convolutions.

The pons Varolii and medulla oblongata are supplied in the following manner:

The basilar artery gives off vertical branches, which supply the nuclei of origin of the nerves and the ependyma of the fourth ventricle. The nuclei are also supplied by small vessels, which enter with the roots of the nerves.

The inferior cerebellar artery supplies the lateral parts of the medulla and the inferior cerebellar peduncle. The remaining portions of the pons and medulla, and the cerebellum, are supplied by the transverse and cerebellar arteries.

The vessels which enter the substance of the brain from the base are terminal arteries, *i.e.*, there is no anastomosis between the distribution of one vessel and the adjacent ones. A certain amount of anastomosis exists between the vessels which ramify in the pia mater, but this is very often insufficient to compensate for the anæmia produced by the plugging of one of these arteries.

When a terminal artery is completely obstructed by an embolus, the supply of arterial blood to the distribution of the vessel is shut off. According to Cohnheim, the reflux of blood from the corresponding vein will gorge the capillaries with blood. Litten believes that the filling of the capillaries is due to the influx of blood from the capillaries of adjacent regions. If the blood-pressure is too feeble, however, this feature is not observed.

As a result of the cessation of circulation in the territory supplied by the obstructed vessel, the nutrition of the capillaries and veins becomes impaired, and they therefore permit the escape of red blood-globules. Then the tissues which have been deprived of blood undergo simple fatty degeneration, and a hæmorrhagic infarction is produced. Finally, absorption occurs, leaving a cyst containing clear fluid.

If a reflux of blood into the vessels does not take place, the infarction has a yellowish or whitish color from the beginning, but in other respects the course is the same as that just described. The retrogressive changes (necrobiosis) probably begin at the end of thirty-six or forty-eight hours.

Unlike other organs of the body, embolism of the brain does not often produce a hæmorrhagic infarction, but almost always results in a patch of yellow or white softening. The reason for this difference is not very clear.

When the embolus is lodged in one of the vessels supplying the cortex, the effect produced varies according to the size of the vessel, and the extent to which it anastomoses with surrounding ones. Infarctions in this region are usually of small size, though they occasionally attain much larger dimensions than those situated within the brain, particularly if a large branch of the middle cerebral artery has been occluded. The color of the infarction is yellow or brown, and the external surface is often extremely hard. It diminishes in extent toward the interior, and sometimes involves only the gray matter of the convolutions. The pia mater above the lesion is usually infiltrated with fluid, and is readily detached from the surface.

In old cases in which the motor regions have been involved, either within the brain or in the cortex, descending degeneration of the pyramid tracts occurs as it does in cerebral hæmorrhage. Moreover, I have occasionally seen atrophy of the unaffected parts of the hemisphere after extensive lesions of this kind, though not to so marked an extent as that which we have described as occurring in cerebral hæmorrhage.

Clinical History.—From the nature of the disease, the symptoms of cerebral embolism always begin suddenly. The attack may or may not begin with a disturbance of consciousness, and, as in cerebral hæmorrhage, this may vary from a passing vertigo or feeling of confusion to complete and profound unconsciousness. General or unilateral convulsions also constitute a not infrequent accompaniment of the attack. The symptoms during the stage of unconsciousness differ in no respect from the corresponding ones of cerebral hæmorrhage, but they are not apt to be so prolonged, and moreover, there are no characteristic phenomena connected with the bodily temperature. There is usually a slight rise of temperature soon after the development of the seizure, but afterward it varies irregularly from time to time. In fatal cases the temperature usually rises steadily until death.

As the embolus is situated commonly in one of the arteries of the left side of the brain (usually the middle cerebral), right hemiplegia usually results, and in a considerable proportion of cases is associated with aphasia. In fact, the sudden occurrence of right hemiplegia and aphasia, without previous head symptoms, is *prima facie* evidence that we have to deal with an attack of embolism of the left middle cerebral artery.

The character of the aphasia differs greatly in individual cases according to the situation of the lesion, and all the different varieties of aphasia may thus be produced (*vide* the article on Aphasia, in this volume). In some cases, indeed, aphasia is the only symptom produced, and may remain permanent without being followed by any other symptom. In a case under our observation it was associated with epileptiform convulsions, which recurred at irregular intervals.

At other times the aphasia is a temporary symptom which soon disappears, but is followed later by an apoplectiform attack, attended with hemiplegia, which then runs the usual course.

The duration of the hemiplegia varies within very wide limits. If recovery does not take place within a few weeks, the paralysis will probably persist for the remainder of life. Unlike the hemiplegia of cerebral hæmorrhage, the paralysis is not so apt to undergo slow but progressive improvement. Recovery takes place either rapidly or not at all in the large majority of cases.

The further course of the disease can be distinguished in no respect from that of cerebral hæmorrhage. As we have stated in our discussion of the latter subject, even a *post-mortem* examination may fail to distinguish in old cases between the remains of a clot and an embolic process, inasmuch as the embolus itself may gradually have been absorbed and the local brain-lesion be replaced by a cyst or cicatrix.

For the changes in the symptomatology due to the varying location of the embolus, we must again refer the reader to the article by Dr. Starr, on Brain, Diagnosis of Local Lesions in.

But we will here refer to a very peculiar group of symptoms, apparently of bulbar origin, which has been observed in a number of instances in which the lesion was situated in another part of the brain. The clinical history of this form of disease is well shown by the following case reported by Berger:

"A man, aged sixty-one, suffering from small, contracted kidneys. In 1883 dysarthria and dysphagia developed suddenly without any violent apoplectiform symptoms. At the end of two days right hemiparesis and salivation were observed. Striking improvement after local faradization. About a year later an attack of tonic rigidity of the body, followed by an exacerbation of the disturbances of speech and deglutition, and also of the right hemiparesis. Paralysis of the orbicularis oris, particularly on the right side, and of the muscles of the tongue and deglutition. Inconstant condition of the glosso-labio-pharyngeal paralysis; no progressive course. No atrophy; normal electrical irritability of the paralyzed muscles."

Quite a number of autopsies have shown that symptoms of this character may be due to a bilateral or even unilateral lesion of the cerebral hemispheres in any position which interferes with conduction from the cortex to the centres of articulation and deglutition in the medulla oblongata, though the latter may be entirely intact. A case of this description, in which I was fortunate enough to obtain an autopsy, was seen by me only a few days ago. In this instance a spot of softening was situated in the anterior third of the posterior half of the right internal capsule, and also involved slightly the anterior part of the optic thalamus.

Diagnosis.—The diagnosis of cerebral embolism has been considered in part in the discussion of cerebral hæmorrhage, so that very little need now be said on the subject.

One combination of symptoms, viz., the sudden occurrence of right hemiplegia and aphasia in a patient who has previously presented no cerebral symptoms, is extremely characteristic of embolism of the left middle cerebral artery. This group of symptoms is observed with comparative rarity as the result of any other lesion, though, of course, a hæmorrhage occurring in the internal capsule may give rise to the same symptoms. In the latter event, however, the disturbance of consciousness is usually more severe than in the former, and, in addition, the onset of the disease is generally not so sudden.

The development, during an apoplectiform attack, of an embolism of the central artery of the retina is very significant of a similar affection of one of the cerebral vessels. Symptoms indicative of the formation of infarctions in the spleen, kidneys, and lungs, may also aid us in coming to a conclusion.

Youthful age and the presence of valvular disease of the heart also point to embolism rather than hæmorrhage. In very young children and infants, however, cerebral embolism is much rarer than hæmorrhage.

If aphasia occurs as the sole symptom the diagnosis must be made from the attendant circumstances, such as the existence of cardiac disease, the occurrence of previous attacks of a clearer nature, the age of the patient, and the subsequent history of the disease.

Berger states that the pseudo-bulbar symptoms mentioned in the preceding section are distinguished from glosso-labio-pharyngeal paralysis by the following differential features:

1. Sudden apoplectiform development of the symptoms, which present no tendency to progression.
2. The presence of other cerebral disturbances.
3. The absence of atrophy of the paralyzed muscles, even after the disease has lasted a considerable time.
4. The absence of degeneration reaction.
5. The intact reflex irritability of the paralyzed muscles.
6. The absence of signs of progressive muscular atrophy.

Prognosis.—This depends mainly upon the situation and character of the artery—whether terminal or not—in which the embolus has lodged, and upon its complete or incomplete occlusion. The latter factor is of comparatively slight importance, since incompletely occluding emboli usually are converted into completely occluding ones from the secondary deposition of a thrombus. As a matter of course, the occlusion of one of the vessels supplying the pons or medulla may prove rapidly fatal.

If improvement occurs it usually takes place within one or two weeks. Otherwise the symptoms remain stationary or are complicated at a later period with secondary contractures, etc., as in cerebral hæmorrhage. According to our experience, there is less danger of mental impairment than in cerebral hæmorrhage. Relapses may occur at any time from the continuance of the primary cause. Death occurs much less frequently than in hæmorrhage of the brain, unless the embolus lodges in the basilar artery.

CEREBRAL THROMBOSIS.—*Etiology.*—Thrombosis of the cerebral arteries is generally the result of atheromatous degeneration of the vessels. In such cases the current of blood is also usually slowed on account of weakness of the heart's action, and coagulation, therefore, takes place upon the roughened parts of the inner coat of the vessel. The deposit of coagulated blood gradually increases in extent, until, as a rule, the lumen is entirely occluded. In rare instances, however, a parietal thrombus forms, leaving part of the lumen free for the passage of blood.

As we have stated previously, it is quite common to find, also, that a secondary thrombus is deposited upon a cerebral embolus, whatever the origin of the latter may have been.

A syphilitic affection of the walls of the vessels may lead to thrombosis in the same way that atheroma does, but the syphilitic vascular lesions have been discussed under a separate heading.

As atheroma of the vessels is usually one of the accidents of advancing age, so thrombosis is also most frequent after middle life.

Another variety of cerebral thrombus is that known as the marasmic thrombus. This develops in intact vessels as the result of simple retardation of the current of blood (perhaps associated with a change in its chemical constitution), and is observed usually after protracted, exhausting diseases, or severe attacks of an acute infectious disease. This variety is also observed in childhood, from similar causes.

Another form of thrombosis is the result of direct compression of the vessel, either from a mass of surrounding exudation, particularly in tubercular meningitis, from the growth of a tubercular new-formation through the wall of the vessel, or from the pressure of a tumor of the brain. In such cases, however, the clinical history of the thrombus is usually lost in that of the primary disease.

Clinical History.—Cerebral thrombosis is frequently preceded by prodromal symptoms, which vary greatly in character and duration, lasting at times for many months. These symptoms are due probably to the impaired nutrition of the brain, on account of the slowly increasing diminution of the elasticity and calibre of the affected vessel.

Dizziness is one of the most common prodromal manifestations; it may be constant or intermittent, and is often aggravated by any sudden change in position. Violent headache is more infrequent, and is usually diffused over the entire head. The patient grows moody and morose, the memory is weakened, and impairment of speech may also be noticed. Sometimes intercurrent attacks occur, in which the individual partly loses consciousness, experiences numbness in an arm or leg, and, perhaps, has a slight loss of power in these parts.

After a longer or shorter duration of the prodromal stage, the symptoms proper of the thrombosis usually develop with great rapidity. Sometimes, indeed, the attack is as sudden as one caused by embolism or hæmorrhage, and if no previous symptoms have been observed, it may be impossible to make a differential diagnosis. The symptoms of the attack itself can usually be distinguished in no respect from those of cerebral hæmorrhage, but there is some difference to be noted in the subsequent history. Recovery from the paralysis which has been produced is extremely exceptional. On the contrary, the impairment of motion grows more marked with time. This feature is explained in part by another peculiarity of the affection, viz., that very commonly the mental power becomes steadily impaired after the attack

of paralysis. If several seizures occur (as is not infrequently the case), the patient gradually sinks into a condition in which he forgets almost everything, and even fails to attend to the wants of nature; his speech is thick and indistinct, etc.

The symptoms due to thrombosis of the basilar artery are so peculiar that they merit separate consideration.

The symptoms develop suddenly or gradually, according to the mode of development of the thrombus.

Sometimes merely a severe apoplectic attack is produced, accompanied often by contraction of the pupils and irregular breathing, the attack proving fatal in a period varying from a few hours to several days.

But usually very characteristic phenomena are developed. If hemiplegia is present (and this is usually the case), it is generally of the so-called "alternate" type (Gubler). In this form of hemiplegia the body is paralyzed on one side and the face on the opposite side (the paralysis of the facial nerve involves the occipito-frontalis and orbicularis palpebrarum, and is, therefore, similar to peripheral facial paralysis). In addition, there is another very rare form of alternate hemiplegia, in which the face and body are paralyzed on the same side, the motor oculi communis on the opposite side. Leyden proposes to call the former variety inferior alternate hemiplegia, the latter variety superior alternate hemiplegia.

In addition, disturbances of speech and deglutition are frequently produced, the former more commonly than the latter. The difficulty of speech is shown by the thick, muffled articulation, and is due to paresis of the muscles of articulation; in other words, it does not present the characteristics of any of the forms of aphasia. The tongue is usually moved with difficulty. The bodily temperature is apt to rise very high in these cases shortly before death, and Eichhorst has reported a case in which the temperature reached 108° F.

Despite the gravity of the lesion, some patients make a tolerably complete recovery, and again become able to walk about, until a further extension of the disease produces a second and fatal attack.

Diagnosis.—As we have on several occasions remarked, the symptoms of an apoplectic seizure due to cerebral hæmorrhage, embolism, and thrombosis, may be identical with one another. But the attendant circumstances are often of such a nature that we shall be enabled to distinguish cerebral thrombosis from the two other affections mentioned.

When the prodromal stage is very long and the attack itself develops slowly, the recognition of thrombosis is usually quite easy. But when these conditions do not hold, the diagnosis depends chiefly upon the age of the patient, the condition of the blood-vessels (particularly the radial and temporal arteries), and the subsequent history of the case.

Furthermore, it is characteristic of this disease that it is very often attended by a gradual, pronounced failure of the mental powers, so that the patients finally sink into a demented condition.

In a large proportion of cases, however, it is impossible to make a diagnosis between cerebral hæmorrhage and thrombosis.

Prognosis.—The prognosis, as regards complete recovery, is extremely unfavorable, not so much on account of the severity of the lesion itself, but from the fact that the vital powers are usually at such a low ebb that restoration of function in the affected parts is impossible.

Sometimes a considerable interval elapses between the individual attacks, but the disease is always progressive, and unless carried off by an intercurrent disease, the patient gradually sinks into a condition of imbecility, finally gets up bed-sores, etc.

Treatment.—During attacks of cerebral embolism or thrombosis very little can be done beyond keeping the patient perfectly quiet. When indicated by the pulse, stimulants should be administered to rouse the failing action of the heart.

After the primary attack has passed over, the treatment of the residua of embolism will be essentially the same as that advised concerning cerebral hæmorrhage.

After thrombosis, the paralysis and other symptoms do not yield to treatment, and little need be done beyond keeping up the general nutrition of the patient.

Leopold Putzel.

BRAIN, HYPERÆMIA OF. A term used to signify augmentation of the mass of blood in the vascular department of the brain. An equivalent meaning is conveyed by cerebral congestion. Both terms indicate in the main an extra physiological accumulation in the circulation of the encephalon, and express the same cause united to different symptoms, although congestion would seem to apply rather to the sudden or the so-called fluxionary hyperæmias. Some writers claim, however, that increase of arterial blood passing through the encephalon is the only true hyperæmia, and that fulness of the brain should more properly be described by "venous congestion," which is rather associated with anæmia.

Like that of many questions in medicine, the history of cerebral congestion is old and so completely chaotic that in recent times the possibility of its occurrence, and consequently its clinical importance, have been doubted. Putting aside its existence as a separate disease, or as a morbid entity having pathognomonic and regular symptoms, we will assume that the brain, like any other organ may be the seat not only of anæmias but of hyperæmias, either circumscribed or generalized. Analogical justification so obvious as that furnished by experimental investigation on the lower animals, having reference to venous hyperæmia, renders the possibility of increased vascularization of the brain admissible. Further evidence that the contents of the cranial cavity may vary in quantity is furnished by the intracranial pressure detected in infants in whom the fontanelles are open, the scalp being raised above the level of the skull, or depressed, according as the head is raised or lowered, or when the tension of the fontanelle is increased by compression of the jugular veins. Where a portion of the brain is exposed, after an injury of the skull, it will be observed to enlarge and to contract in correspondence with the elevation or depression of the head, the presence or absence of sleep and emotional excitement, or with the action of any cause that accelerates the circulation. Any cause that constricts the neck may produce a sensation of fulness and pain about the head, with bleeding from the nose; and as a fact of pathological moment that should be emphasized, there may be mentioned the obstruction to the flow of venous blood resulting from insufficient removal of carbon dioxide. In dependent positions of the head, indications of congestion are noticeable in the bloodshot countenance and other evidences of imperfect return of blood. The existence of intracranial congestion under such circumstances is further demonstrated by the very red papillæ and much congested vessels of the optic nerve. These changes at the fundus of the eye are not found in such gymnasts as trapeze performers and "fly-walkers," because by constant training and habit the animal economy accommodates itself to the abnormal positions. Variability of the cerebral circulation is further shown in the pallor of the fundus of the eye, following the administration of drugs that are known to irritate the vascular nerve-centres, as ergotine and belladonna. Finally, the existence of cerebral hyperæmia is revealed by the necroscopic appearance of the brains of persons or of animals who during life suffered from interruption to the perfect return of blood from the head.

It is more difficult to recognize cerebral hyperæmia on the cadaver, since evident traces are not always left in the brain, and there may be sanguinary stases brought about by gravity and the position of the cadaver which do not exist during life. Venous hyperæmia is more easily recognizable after death than the arterial form. In a severe case of hyperæmia the tissues over the cranium are often found to contain an abnormal quantity of blood; drops of extravasated blood from ruptured vessels are seen on the dura after removing the calvarium; the dura mater, when detached, is of a bluish tint; the sinuses of the dura, the veins emptying into the sinuses, the veins of the pia and the choroid plexuses are distended with

blood; and degeneration of the vessels themselves has been frequently observed. The mass of the brain appears larger and swollen, the convolutions and the gyri are flattened, the sulci are effaced, the ventricles may be filled from subarachnoidean effusion, there is a reddening of the whole organ, and the membranes are dry and viscous. This reddish or deep-red tint is particularly noticeable in the intense hyperæmia of the new-born.

The gray substance, increased in consistence, presents a reddish-gray color, and if the hyperæmia has been intense, small punctiform hæmorrhages are observed. The white substance, also increased in consistence and in density, is of a uniform rose color. On section the brain, without being œdematous, shows numerous sanguinary points which are larger than usual, owing to increased size of the capillaries. The meninges are usually filled, and the veins of the cortex are tortuous. If the case has been a chronic one, uniform widening and tortuosity of the vessels is much more pronounced, showing the development of small aneurismal dilatations, and sequelæ conditioned by the increased vascularization, such as vascular development of the cellular tissue which enters into intimate relations with the glia. The cribriform or sieve-like appearance observed on making a transverse section of the hemispheres is usually regarded as a consequence of long-standing stasis, especially if found in the brains of old people, of chronic drunkards, opium-eaters, or of maniacs. There are also reasons for believing that cerebral atrophy may be developed in old people in consequence of continuous venous stasis. The pathological changes of arterial hyperæmias peculiar to the cranial cavity are rarely observed on the cadaver, as they usually disappear, with its causes, after death. When we take into consideration the imperfect knowledge both of its mechanism and of its anatomical details, and the difficulty to establish the relations existing between its numerous symptoms and the lesions that determine them, it is not surprising that the existence of cerebral hyperæmia is not always easily demonstrable. The condition may sometimes be studied on the large arteries of the pia, but no one has yet distinguished an arterial from a venous hyperæmia in the cortical portion of the brain. It is only in such processes as Basedow's disease that chronic arterial hyperæmia is recognized. The difficulty of recognition is increased by the inflammatory changes and simple hyperplasias that are often present, and often overlooked after frequent and long-continued attacks of chronic arterial hyperæmia. According to recent researches, when the disorder has run a rapid course, pathological changes may be found in the ganglion cells, or in the cortical connective-tissue, with nuclear proliferations in the walls of the vessels, and in the fibrillary plexus of the cortical substance.

If there exist a disproportion between the clinical and the post-mortem phenomena of cerebral hyperæmia, it must be admitted that the mass of the blood within the skull varies according to certain circumstances, and that the brain, like other organs of the body, is subject both to anæmia and to hyperæmia; indeed it would be surprising if it were not. The question of hyperæmia resolves itself into that of a liquid circulating in tubes, in which repletion or engorgement can be produced in but two ways, namely, by increase of the inflow, or by diminution of the outflow. Active fluxionary hyperæmia may be caused by the augmentation, and passive hyperæmia, or that of stasis, by diminution of the sanguinary flow. The force and abundance of the inflow of blood into the vessels of the brain is influenced by the general increase of pressure, and by diminution of local resistance, and it seems as if the greater number of active congestions should be brought under the first category. For a long time the congestive influence of certain exciting drinks, as tea, coffee, and alcohol, has been admitted; and violent muscular exertion, general plethora, cardiac hypertrophy, emphysema of the lungs, the effects of strong emotion, and the exaggeration of normal functional activity, are believed to take great part in the production of cerebral congestion. But the general increase of blood-pressure plays simply a secondary part in the production of hyperæmia, which it can only facilitate or augment when there exist local alteration, such as inflammations or vascular lesions. Hypertrophy of the heart can scarcely be said to cause congestion of the brain, except in cases in which the cerebral vessels have become weakened on account of other causes, and the same may be said of other agents that increase the cardiac impulse.

Other conditions that tend to produce congestion of the brain, by excess of arterial tension and too considerable afflux of blood, are chronic Bright's disease, Basedow's disease, intermittent fever, extremes of heat and cold, and the tension produced in the vessels of the head and neck when the aorta is constricted or strongly compressed by a thoracic or an abdominal tumor. This increased arterial tension may also be brought about by the suppression of the normal or pathological secretions, as the menses at the menopause or other period, by the sudden stoppage of hæmorrhoidal bleeding when general plethora exists, by the checking of a chronic diarrhœa of long standing, or by stopping the hæmorrhages in hæmatophilia, and it may result from facial erysipelas, or any cerebral or meningeal phlegmasiæ, from diverse peripheral irritations, from extended lesions of the skin produced by burns and eruptive diseases, as variola, scarlatina, and measles.

An important and considerable class of congestions may result from local increase of pressure or collateral fluxions, by means of which the entrance of blood is shut out from the organs. The pathological phenomena susceptible of giving place to collateral fluxions are acute inflammations, thromboses, and embolisms, and the infarctions resulting therefrom. Interstitial hæmorrhage may have the same result; and the energetic local compression excited on the skin by the application of thick layers of collodion also produces a considerable local hyperæmia. Fluxionary hyperæmias from exaggeration of pressure result from general pressure only, not from local, and the greater part of them result from the pathological causes above mentioned.

Hyperæmias of fluxion, by diminution of local resistance, may result when atmospheric pressure is diminished or defective, the simplest type of which is furnished by the application of the large exhausting apparatus used to produce cutaneous revulsion. The opposite condition may bring about the hyperæmias peculiar to workmen in condensed air. The congestive phenomena brought about by the rapid disappearance of a considerable effusion, as ascites, and even by the extirpation of certain tumors, belong to the same category. The condition is also brought about by direct or reflex paralysis of the vaso-motors which influence the dimensions of the vessels in the brain cavity. The innervation of the vascular walls may be directly diminished by any pressure whatever, as that of a tumor, or they may be paralyzed by reflex action in consequence of an irritation of the sensitive nerves of a part, as observed in inflammation and in lesions of the nerve-centres. Direct paralysis of the muscular walls of vessels may be brought about by variations of temperature. Extreme heat and cold and insolation are capable of producing intense congestion, and the action of rubefacients is analogous. Direct insolation doubtless acts by raising the temperature of the cranium to such a degree as to cause incipient paralysis of the muscular action of the vessels, and consequent diminution in the tonic force of their walls. The same nervo-vascular phenomena are asserted to be brought about by the action of such substances as opium, alcohol, belladonna, hyoscyamus, haschisch, stramonium, and amyl nitrite. Fatty or amyloid degeneration of the vascular walls, especially in old people, transforms the vessels into inert and dilatable tubes, which may favor hyperæmias of this order. The presence of entozoa, or of any pre-existing focus of disease in the brain, is also an etiological factor. Finally, all the processes that decrease intracranial pressure favor the creation of cerebral hyperæmia. Among them must be reckoned such causes as intense excitement, no matter whether produced by imagination, temperament, or thought. Intellectual work that consists in logical combinations of ideas seems to be less hurtful in

this respect than the more exciting results of a heated imagination, or the depressing effects of sadness, sorrow, and sudden shocks.

Passive hyperæmia, or the hyperæmia of stasis, may result from the active or fluxionary form. It happens that the capillary vessels do not regain their first tonicity after the enormous distention of an active hyperæmia, so that the stases become confused with the preceding fluxions. The causes of hyperæmia by stasis are principally those that retard the return of blood from the brain, either by diminution of the local pressure or by increase of the obstacles opposed to the returning circulation. The former exists in the case of alterations of the arterial walls, or when their contractility and elasticity are lost, and in obliteration of the arteries; the second is seen in the hypostases of certain congestions resulting from the long continuance of one position of the body, or in those following certain maladies, and in the compressions of the venous system by tumors or any neoplasm whatever. Venous congestion or hæmorrhagic stasis may result from thrombosis, or it may result from congestion of the vena portæ, from compression of the jugular, from a stasis in the region of the lesser circulation, from mitral insufficiency, emphysema, and stenosis of the larynx, from all forced expiratory efforts made with closed glottis, and from all processes that invade the abdominal cavity, especially in plethoric individuals. Chronic constipation and flatulence, blowing wind-instruments, violent vocal efforts, parturition, epilepsy, hysteria, and chlorosis, are all at fault in producing this variety of hyperæmia.

Although no one sign of cerebral hyperæmia is of absolute diagnostic value, yet its existence is often established by the symptoms alone. Fluxionary hyperæmia constitutes rather a phenomenon superadded to various morbid states, but in certain cases of mental alienation over-activity of the mind, though always secondary, is very nearly the only pathological manifestation. As in anæmia, the symptoms met with in exaggerated distention of the vessels of the brain are those arising from derangements of the sensorium, the organs of special sense, and of the sensitive and motor nerves. The manifestations of cerebral hyperæmia are perhaps better known to alienists and neurologists than to other physicians. They are most important as throwing light on the general pathology of insanity, many cases of which, having unknown or undetermined lesions, are doubtless owing to encephalic congestions. Of the cerebral functions the most strongly affected is the intelligence. Delirium is the prominent symptom of cerebral hyperæmia. It is generally that of excitement, and in many cases in no way connected with general paralysis there are found to predominate the delusions of grandeur, riches, ambition, and the like, characteristic of congestive mania. The superactivity of the cerebral circulation, as well as that of thought and well-being, may be recalled in the rosy excitement produced by wine and good cheer, in the artificial excitement of poetic frenzy, in the beatific visions of psychopathic women, and in religious ecstasy. Insomnia is one of the surest signs of hyperæmia of the brain. In many cases mania and certain hallucinations are connected with a notable hyperæmia of the gray layer. The delirium of febrile congestion, which is of a more distressing character, is owing less to quantity than to the quality of the blood, which is warmer, and besides charged with pyrogenic substances, as miasms, pus, and the like.

General hyperæsthesia most often coincides with furious delirium, and headache also exists in a great number of cases. The troubles of the organs of sense are characterized by excitement and irritability. It is claimed that paræsthesia may be detected with the æsthesiometer. Generally the pupil is contracted. This has been noted in the greater proportion of cases. Paralysis of the dilator, or irritation of the sphincter is met with. Photophobia, ocular spectra, and ringing in the ears are symptoms peculiar rather to cerebral anæmia or to the venous variety of hyperæmia. The ophthalmoscope teaches but little in regard to cerebral hyperæmia. Its use has, however, justified the supposition of a transitory vaso-motor paralysis during frequent and severe attacks of cerebral congestion in a case of hysteria with paralysis and other symptoms. Diplopia and illusive transformations of hearing are often present with the other derangements of the special senses. Recent observations point to the connection between tympanic congestion and cerebral hyperæmia. Examination of the membrana tympani appears to indicate the state of the cerebral circulation, a fact demonstrated by comparing the state of this membrane before and after the administration of quinia or amyl nitrite. It is remarked, in connection with this circumstance, that evidences of congestion are noticed in the vessels over the handle of the malleus, and that the membrana tympani is of a light pinkish color. There is also a rise of temperature in the external auditory canal.

Motor disorders are seen in the agitations and struggles of the patient. There may be numbness and formication of the extremities, but paralysis does not in any way belong to arterial hyperæmia. Convulsions are most common in infants, and belong rather to anæmia or venous stasis than to arterial hyperæmia, and they may be confounded with epilepsy. The vomiting sometimes met with belongs also most often to anæmia. The circulatory apparatus is more or less disturbed in cases of active congestion. There is palpitation and a sense of oppression; the pulse is full and rapid and the carotids pulsate. This morbid excitability of the heart is particularly influenced by emotional disturbance. There is, however, a difference of opinion as to its symptomatic importance. Reflex excitability is preserved.

The phenomena of venous or passive congestions are in reality those that commonly relate to anæmia of the brain, and in a given case of anoxohæmia it is difficult to recognize whether the condition be owing to want of blood in totality or to venous stasis. In a venous stasis from thrombosis of the sinus or from embolism the symptoms present are similar to those of congestion, namely, derangements of the intelligence, the sensibility and motility, and sometimes there is an agitated state of mind, with dilated pupils. Vertigo, photophobia, auditory subjective phenomena, and incoherence of ideas exist, however, to a less degree in this form than in the fluxionary, and in the case of delirium it is rather of the mild or demented kind. The symptoms of cerebral hyperæmia may vary according to age, sex, and other circumstances. Men are more subject to it than women. The different periods of life known as increase, maturity, and decline, are modifying influences, but it does not appear that season exerts any influence. The symptoms may be light or severe, and they may be acute or chronic.

In a case of acute fluxionary hyperæmia the patient may, after a short premonitory headache and dizziness, fall senseless, with or without convulsive movements. The face is red, the conjunctivæ injected, the pupils contracted, the temporals and carotids pulsate vehemently, the pulse is hard and strong, the respiration stertorous. There are often convulsive movements and twitchings, especially in children, combined with slight paresis, and the condition often ends in stupor and death. If the case do not terminate fatally, the symptoms decrease in severity and disappear entirely, or they may pass into the chronic form. The latter is characterized by a sense of fulness and heaviness in the head, by continuous or paroxysmal headache, dizziness, and pulsations of the temporal and carotid arteries. These symptoms become worse by lowering the head, and by the influence of alcohol, if the hyperæmia is still active. The frame of mind is rarely serene, the patient is morose, excitable, and explosive. There is a disinclination to mental labor, with confusion of thought, the combinations of which are illogical, morbid, and exaggerated; and symptoms of morbid apprehension, like those common to agoraphobia, are often present. A morbid fear of impotence is a predominant idea in this condition. Other symptoms arrange themselves according to the fundamental conditions that originate the exaggerated distention of the cerebral vessels.

The symptoms of passive hyperæmia are not entirely identical with the foregoing. There is more apathy, and

the patient is more depressed. It should be taken into account that the poisonous influences of carbon dioxide obtain in this condition: it is the defect of oxygen in the venous blood, and not its quantity, which causes the characteristic phenomena.

The diagnosis of cerebral hyperæmia is often not clear, because of the likeness of the symptoms to those of anæmia. The question here concerns the symptoms that have already been mentioned in connection with the excitements of the three great faculties of the nervous system, another enumeration of which would be tedious. In the delirium of anæmic origin, as in grave fevers and inanition, the aspect of the patient is quite the opposite of the flushed face, the brilliant eye, and general rugged appearance so often associated with hyperæmic delirium. The essentially transitory character of the excitement met with in these cases, the syncope and convulsions, leave no doubt as to the anæmic cause of the delirium. Delirium tremens and a certain kind of delirium from lead-poisoning resemble in some points the delirium of cerebral hyperæmia, but the discrimination is easy when attention is directed to the history of the case and a knowledge of the patient's habits. Elevation of temperature is of use in distinguishing inflammatory diseases of the brain from hyperæmia. The latter condition is usually apyretic, but at times it is possible to detect an elevation of one or two degrees above the normal by means of the differential calorimeter applied to different regions of the head. Vertigo, epilepsy, uræmia, embolism, thrombosis, softening, and hæmorrhage may be confounded with cerebral hyperæmia; but each of these affections may be distinguished after careful examination into the condition of the urine, the heart, lungs, and blood-vessels, and on comparing the symptoms of the before-mentioned diseases with those of hyperæmia.

The prognosis of cerebral hyperæmia depends upon the intensity and duration of the symptoms as well as on individual circumstances. Children are more liable to succumb to the intensity of congestion, and in old people cerebral congestion is particularly dangerous, because of the tendency to rupture in the degenerated vessels. Strong cerebral congestions are as grave as cerebral hæmorrhage, and may lead to death. They may also prove the immediate cause of death in such chronic conditions as tumor of the brain and senile degeneration of its vessels. The tendency to such secondary lesions as hæmorrhage, softening, cerebritis, and the like, is greatly increased by the frequency of the paroxysms. Active cerebral hyperæmia, being more amenable to treatment, is consequently more favorable to recovery, than is the passive variety.

The chief therapeutic indication in acute fluxionary hyperæmia is to diminish the sanguineous afflux, and this is perhaps best done by judicious inaction and careful watching of the symptoms. The condition is not one either of pressure or of œdema, but of an over-active circulation, and the treatment must vary according as the causes are primary or secondary. The nature of the treatment of active congestion from such causes as extremes of temperature, insomnia, or other irritable condition of the brain, will, of course, differ from that required by the secondary congestions caused by suppression of the menses, by gout, or by rheumatism. Rest and position are of primary importance during an attack. The head should be elevated and the arms stretched upward. Quiet surroundings, fresh air, and a darkened room are advisable. Local bleeding is recommended by most practitioners, but it should be done with a certain amount of discretion and caution. As a rule it is contraindicated in children and old people, and in hysteric or chlorotic persons. The so-called derivation and revulsion, in which a considerable congestion of the whole or part of the intestinal canal is produced by the administration of a drastic purgative, may diminish the afflux of blood to the brain. In fact, main reliance is to be placed upon the derivative effects of croton-oil, colocynth, and irritating enemata, as of vinegar; the irritation of hot, or mustard, baths for both the hands and feet; and the production of diuresis. Reflex action is further brought about by the application of a mustard-plaster to the epigastrium, and the actual cautery to the nape of the neck. Cold vigorously applied to the head, in the form of ice, or cold douches upon the head, combined with a hot bath, are adjuncts in the treatment too valuable to be overlooked. Where there is a heart complication it may be met with cardiac medicaments. Among the internal remedies that it is advisable to employ as agents in relieving the cerebral congestion are the bromides, ergot, oxide of zinc, eucalyptus, and hydrobromic acid. When the symptoms of congestion have disappeared, strychnia, phosphorus, and cod-liver oil may be administered with advantage, and at the same time the patient's nervous system is to be carefully nursed. This is particularly to be enjoined in the case of chronic hyperæmia. Complete intellectual rest, fresh air, regular habits, and the disuse of tea, coffee, alcohol, and tobacco should form part of the hygienic treatment. The milk-cure and the grape-cure may be mentioned as valuable dietetic measures. If the congestion arise from stoppage of a hæmorrhoidal flow, leeches may be applied to the anus. Wonderful effects have been thus brought about. Like results have been obtained by applying leeches to the mouth of the uterus in secondary hyperæmia caused by suppression of the menses. In this condition the electric brush applied to the thighs, with douches to the loins and perineum, has been found efficacious in restoring the menses. Galvanization of the head and of the sympathetic nerve, having the power to contract the cerebral blood-vessels, may often be used with good effect. A systematic course of hydrotherapeutics is often advantageous.

In passive hyperæmia the causes are to be made the special objects of treatment. Generally, it is a question of restoring vascular tonicity and combating symptoms that in many respects resemble those of cerebral anæmia. Stimulants may be administered in many cases. Satisfactory results have been obtained from ether inhaled in small quantities. The use of cardiac tonics, as digitalis, when the stasis results from some vascular or cardiac lesion, or when there is cirrhosis of the kidney, is a question that still admits of a satisfactory solution.

Irving C. Rosse.

BRAIN, MALFORMATIONS OF THE. Malformations of the brain embrace two classes, according as the individuals presenting them are viable or non-viable.

Class I.—In the first class may be included cases already described among the atrophies of the brain, cases of microcephalus, and of absence of the cerebellum or corpus callosum. To this class also belongs heteropia, a condition in which masses of gray matter are found transplanted into the white, and one which is invariably associated with idiocy. Finally, cretinoid idiocy is associated with a malformation of the cranium, which reacts more or less distinctly upon the brain. The basal cartilages are prematurely ossified, and thus the body of the sphenoid and the basilar process are arrested in their growth, and the base of the skull is shortened. The basilar process is inclined more vertically than normal. The vault of the cranium expands, and the brain is forced upward into it from the base. The basal ganglia are relatively crowded for room, and it is probable that the ganglionic motor centres are imperfectly developed; hence one cause, at least, of the muscular inertness of cretins.

Class II.—Non-viable malformations of the brain constitute monstrosities. These have been divided by Isidore St. Hilaire into three classes, forming together the third tribe of his autosite monsters. These classes are called respectively, exencephalians, pseudencephalians, and anencephalians. In the first class the brain exists, though malformed and small, and protrudes through an opening in the skull, forming a hernia or encephalocele. Sometimes the membranes enclosing it contain also serum, and the hernia is then called hydrencephalocele (Ackerman).

In the pseudencephalians, the brain is destroyed and replaced by a reddish mass, consisting of membranes and bundles of engorged blood-vessels. This mass also pro-

trudes through the skull, no longer through a single cleft, but through a large opening left by the complete absence of the cranial vault.

In the anencephalians, finally, the cranial cavity is entirely empty. The cases vary according as the cerebral defect is, or is not, complicated with spina bifida, or even an absence of the spinal cord. Thus there is an anencephalia simplex, an anencephalia cum amyelia, and an anencephalia cum spina bifida.

Cases of encephalocele are further subdivided into notencephalon, when the tumor occupies the occipital region; proencephalon, when it is in the frontal region; and podencephalon, when it perforates the cranial vault by a pedicle. In the fourth subdivision, hyperencephalon, the cranial vault has disappeared; in anencephalon there is an analogous defect at the occipital region, coinciding with a cleft in the vertebral column. Finally, in exencephalon, the fissure extends through the cervical vertebræ, while the vault of the cranium is also wanting. The spinal cord is absent, but the spinal nerves persist.

In the first three genera the cranial tumor may be covered with ordinary skin; or this may be so thinned as to be rendered transparent. The hernia always takes place on the median line, and through the natural openings between bones, or the united symmetrical segments of bones; thus between the two halves of the squamous portion of the occipital, or of the vertical portion of the frontal, or between the two parietal bones.

The notencephalon is the most frequently encountered malformation of this class, and compatible with the greatest degree of viability. A (probably apocryphal) case is mentioned by St. Hilaire, of an individual, a Russian, affected with this malformation, who, nevertheless, attained adult life, and the possession of some intelligence. The notencephalon is the first link in the chain of monsters, which leads by insensible gradations to the acephalians, deprived not only of brain, but of head. The teratological series is almost as complete as a zoölogical series could be (St. Hilaire).

Proencephalon is much more rare. In 1677 a case is reported, when the child is said to have lived four days. Small meningoceles are less uncommon, and may persist after closure of the frontal suture, as a soft tumor lying at the root of the nose, and not interfering with the well-being of the child. We have seen such a case. In the first three genera of this teratological series the cerebral tumor protrudes between simply separated bones; in the last three, large openings are left because the bones are atrophied. They are also flattened, partly from loss of intracranial pressure when the cranial contents have been evacuated, partly from the backward traction exercised when the tumor is situated posteriorly. The vertical plates of the frontal bone become nearly horizontal, the upper border of the orbits becomes posterior to the lower, the parietal bones are flattened, the superior occipital bones are atrophied, and increasingly so as the series progresses from the notencephalon to the exencephalon. The face is oblique.

At the base of the skull the bones are intact. The capacity of the basal fossæ is greatly diminished from diminution of their contents, but there is no synostosis of the articulations. The anterior part of the body of the sphenoid bone is, however, drawn upward, and thus the angle between its long axis and the plane of the occipital foramen is diminished.

The lesions are all thus concentrated upon the cranial bones which are formed in membrane, as distinguished from those which develop from the primordial cartilage. It is these same bones, moreover, which, lying on the periphery, receive the full force of excessive intracranial pressure.

These facts speak against the hypothesis of a simple arrest of development as the cause of the malformation. They point rather to a rupture of the cranial shell under the influence of a morbid increase of intracranial pressure. This, again, is due to a dropsical effusion, dependent probably on irregularities in the circulation, or an imperfect structure of blood-vessels.

The cranial bones formed in membranes begin to ossify at three and one-half months. The rupture of the membranes usually occurs at one or two months before the middle of pregnancy, when the brain is completely destroyed, but it may occur later, when the destruction is only partial.

The pseudencephalian monstrosity is of a different nature. As in the first class, there is a tumor which protrudes from the cranium, but this does not consist of brain substance and serum, but of a mass of engorged blood-vessels enveloped in membranes, and from which nervous tissue has almost entirely disappeared. The destruction seems due to an intense hyperæmia, or even inflammation. The tumor is reddish, covered externally by a thin transparent membrane, divided internally into lobes, a division probably correlated with the ramifications of the hypertrophied blood-vessels. The carotid and basilar artery can generally be distinguished. The tumor may be as large as, or larger than, the normal brain, but is usually smaller. In this form of monstrosity the mother has usually suffered from some traumatism during pregnancy.

The viability is much less than that of the higher grades of exencephalians, and many subjects die immediately after birth. Others live a few days, or even a week. In such cases, pressure on the tumor seems to irritate the medulla, accelerating the respirations, or rendering them convulsive, or provoking cries.

There are three genera. In nosencephalon (*nosos*, disease) the vascular tumor projects through a large opening on the upper part of the head, left by defect in the frontal and parietal bones. In thlipsencephalon (*thlipso*, I crush), the tumor emerges through the vault of the cranium, but is then prolonged backward so as to occupy the entire occipital region. The posterior fossa disappears, so that there is no distinct occipital foramen. Finally, in the pseudencephalon, the cranium and vertebral canal are both largely open, and the cord is absent. The first two genera are among the most frequent of all human monstrosities, but are never seen in animals.

The anencephalians result from the same morbid process which causes a hydrencephalocele, but which is carried to the farthest possible degree of intensity. It is more frequently met with than the higher grades of the classes already mentioned. Hannover gives nine cases of anencephalia for 10,683 births occurring at Copenhagen in the course of ten years. An anencephalic mummy was found by the French in Egypt, and described to the Academy of Sciences, in 1826, by Geoffroy St. Hilaire. This mummy had been interred among the sacred monkeys at Hermapolis—a proof of the extraordinary impression it had made upon the persons who had been present at its birth.

This monstrosity is twice as frequent in females as in males. Half of the fœtuses are born at term, nearly one-fourth at eight or at seven months, very few earlier. The rupture of the cranial shell, by which its contents are evacuated, usually takes place through the posterior fontanelle. This fact is in accord with the preponderating frequency of posterior hernias among the exencephalians. After the brain has been destroyed, the bones of the cranial vault are gradually absorbed, and thus the original opening is continually being enlarged.

Thus disappear the upper portions of the frontal and the parietal bones, and the squamous portions of the temporal and occipital. The sphenoid, petrous, and basal occipital persist; but the condyloid portion of the occipital is drawn downward and outward, the mastoid portion becoming first oblique, then almost transversal. The body of the sphenoid is deformed, the lesser wings forming two loops.

Cases complicated with spina bifida are about half as frequent as those of anencephalon simplex (Hannover). The spinal column, deprived of its posterior arches, is converted into a shallow canal, covered by a transparent membrane, through which may be seen the spinal nerves. If the defect extend only through the cervical vertebræ, the malformation is called derencephalon. When the cord is completely absent, and all the vertebral arcs, the malformation is anencephalon proper.

It is said that anencephalian monstrosities are peculiar to the human race. This may, perhaps, be due to the more rapid growth of the human brain; hence greater liability to disturbance in circulation, to serous effusions, and to variations in intracranial pressure. The antecedents are rarely traumatic; much more frequently do they consist in profound moral impressions on the part of the mother. A singular case of anencephalon is related, in which the individual was the bastard offspring of a Jew and a Christian woman, and in which, throughout her pregnancy, the mother was tormented by religious terrors. The writer has seen a case, in which the mother, to avert the disgrace of an illegitimate confinement, tried during four months to procure an abortion by means of ergot and the local application of the faradic current.

In the class of monstrosities known as cyclopians, characterized by absence of the nasal apparatus, including the ethmoid bone, the brain is also malformed. It is much smaller than normal, and without distinct convolutions. The anterior part of the cerebrum consists of a single lobe, which lies obliquely, instead of on a horizontal plane. The corpus callosum is rudimentary, and the trigonum is absent, as are also the corpora striata and olfactory bulbs. There is neither median fissure nor falx cerebri. The lateral ventricles are confounded with the median, which represents the original ventricle of the brain. The tendency to fusion of symmetrical halves, upon which these various alterations depend, is especially conspicuous in the fusion of the eyes into a single enormous eye, uncovered by eyelids, and placed in the middle of the forehead (hence the name of the monstrosity, from Cyclops). Similar fusions are often seen in the viscera.

The cyclopian monstrosity originates in an incomplete formation of the anterior part of the primordial cartilage of the cranium (Hannover). The forehead is narrow, and the vertical and horizontal parts of the frontal bone meet at a very obtuse angle. The lower part of the occiput is flattened, the entire skull brachycephalic, the bones ossified and prematurely closed, the fontanelles small. There is a deformed external nose, which, however, does not communicate with the buccal cavity, and thus nasal respiration is impossible; the monsters are non-viable, and die within a few hours after birth. About half are born at term; the rest at six or eight months.

The immediate cause of cyclopia is the failure of the first cerebral vesicle to advance between the optic vesicles. It is on this account that the latter coalesce.

General Etiology of Cerebral Malformations.—These monstrosities have always greatly excited the popular imagination. Until modern times, they have always been explained by an admixture of the human parentage with an extra-human paternity. In a remote antiquity, as is shown by the Egyptian mummy described by St. Hilaire, this unknown parent was supposed to be a god. In the more sceptical ages of Greece and Rome, it was suspected to be an animal, a theory favored by the fanciful resemblance to animals easily traceable in the monster. The theory was also rendered plausible by the universal belief in the possibility of fruitful sexual intercourse between human beings and animals. The gloomy imagination of mediæval times, which saw the devil everywhere, could not fail to find traces of him in monstrous births, and their paternity was attributed to demonic incubi.

The modern substitute for these hypotheses was, for a long time, the theory of maternal impressions received at the moment of conception, or during pregnancy. Injurious impressions have undoubtedly often been produced upon the women who have subsequently given birth to monsters; but, on the other hand, the association is far from being constant. Further, such impressions, to be operative, must occur before the fifth month of pregnancy; yet in many of the most apparently plausible cases the perturbating incident occurred only shortly before birth.

In any case, the mechanism of the influence, even when it exists, is at present quite inexplicable.

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BRAIN, MECHANICAL INJURIES TO THE. The brain is contained in, and protected from injury by, the skull, a bony case which is constructed upon the principle of an arch, and which rests upon two supports, the spinal column behind, and the bones of the face in front (Tillaux). The skull is composed of the vault and base. The former has an outer and inner table of dense bone, separated by cancellated bony structure. The inner table is more brittle than the outer, and, in case of fracture from force applied from without, usually suffers over a larger extent than the external table. The bones entering into the base present much greater irregularity of surface and thickness than those of the vault. The thicker portions are, however, weakened by numerous canals passing through them, which transmit vessels and nerves. The resisting power of the base varies greatly in different parts, at places being only thin plates of bone, as in the horizontal plate of the ethmoid and roof of the orbit, and in others offering broad bony buttresses, strongly supported and capable of resisting great violence, as is found in the condyles of the occipital bone. Closely applied to the outside of the skull is the pericranium, and within is the dura mater, and these two membranes undoubtedly add considerably to its strength and elasticity. In the living, the base of the skull from within does not present the same irregularities of surface and prominent projections as are seen in the dried specimen. These are covered in, and protected in great measure by the dura mater and the great sinuses, and the vessels and nerves passing through the various openings found in the base. The central zone of the base is composed of wedge-shaped masses of bone on either side, the petrous portions of the temporal bones, which run not directly transversely, but obliquely forward. This obliquity is an important factor in the resistance of the skull to blows upon, or crushing force applied to, the sides of the head. The brain-case, as thus constructed, possesses a considerable degree of elasticity, and Felicet has shown that a blow upon the vault may produce a yielding of the bone to the depth of one-third of an inch without fracture occurring, and that the resiliency is sufficient to completely restore the part. As a result of injury, fractures of the skull may be localized at the vault, or may radiate from the vault to the base. Fractures of the base seldom, if ever, occur alone, unless as the result of direct perforation through nose, mouth, or orbit. Again, fractures may be linear, without depression, depressed, comminuted, and compound.

The surface of the brain is bathed with cerebro-spinal fluid, which is found in the subarachnoid space. This fluid is present in the greatest quantity at the base (lacuna centralis), and is continuous with the fluid contained in the ventricles through the foramen of Majendie. Surrounding the arteries upon the surface of the brain are lymph-spaces, known as perivascular spaces, which open into the subarachnoid space, and which also contain cerebro-spinal fluid. It is thus apparent that the fluid upon the surface is continuous with that found in the ventricles, and that it likewise penetrates into the brain-tissue itself by these perivascular channels. Any commotion or movement in this fluid may, therefore, be felt throughout the encephalic mass, and may be followed by increase or diminution of pressure in various parts widely separated from each other, and from the point of original disturbance.

Distention of the perivascular spaces, due to movements in the cerebro-spinal fluid, must produce compression of the vessels within, and a corresponding anæmia of the tissue which they supply. Such contraction is likely to be followed by expansion, or even rupture, when the pressure is removed. This fluid plays an important rôle in the pro-

duction and distribution of the brain-lesions which follow mechanical injuries; for every shock, and any diminution in the size of the intracranial space, must be followed by a disturbance of the existing equilibrium. The effect produced will vary with the degree of the disturbing force, and "the primary effects, in which the arteries may be assumed to be constricted, would be again different from the secondary effects, in which they may be assumed to be dilated." "The sensation of vertigo and noises in the ears," which often follow head injuries, "are probably caused by sudden transportation of lymph-fluid into the posterior cerebellar fossa. In like manner the phenomena, so common in brain disease, of vomiting, of irregular motions of the eyeballs, of paralysis of the facial muscles, of the tongue, or of one or more muscles of the eye, may be often attributed to the pressure of the lymph, either against the nuclei of origin of the cranial nerves lying in the gray matter of the iter, or beneath the floor of the fourth ventricle, or against the nerve-trunks as they pass from their apparent origin to their points of exit" (Allen). The brain being completely covered by the skull, all mechanical injury to it must occur through force applied either directly or indirectly to this bony case, or by foreign bodies which have penetrated the same. Damage to the encephalic mass may be produced without apparent injury to the skull, or may be coincident with, or the consequence of, more or less extensive fracture or contusion of the bones.

Injuries of the brain have usually been considered under the headings of concussion, contusion, laceration, and compression.

A classification into such definite divisions has undoubtedly tended to produce a wrong conception of the conditions which actually exist, and has introduced and perpetuated a great deal of obscurity in this subject; for while a general shaking, or concussion, of the brain may occur without injury to the skull, this condition must be inseparable from all injuries producing fracture, with or without laceration of brain-tissue, and the so-called concussion therefore undoubtedly plays an important rôle in the production of symptoms, immediate and remote, which follow nearly all forms of head injuries. Indeed, the investigations of Duret seem to show that concussion of the brain, pure and simple, as conceived of by the older writers, does not exist, and that there is really no such a thing as "cerebral vibration without visible lesion," but that in all cases there are changes in the vascular supply, disseminated minute extravasations, and actual destruction of brain-tissue; in other words, that contusion and laceration, in greater or less degree, are inseparable from concussion, and with such qualification the word will be used in what follows.

The reaction of the brain to injury depends very largely upon the part affected, and while in certain portions extensive destruction has been followed by no symptoms of cerebral origin, certain constant manifestations always result from even very limited lesions of other portions. The effects of injury may be either local or diffused, and may result in abolishing function (paralysis, anæsthesia) in case of destructive lesions, or of intensifying function (spasm, hyperæsthesia) where there is only an irritative lesion. The important rôle played by the cerebro-spinal fluid in the production of these lesions has already been mentioned.

So-called concussion of the brain may be produced by blows and falls upon the head, or by falls upon the feet, knees, or buttocks. Duret has shown that, if an animal is struck a blow upon the head of sufficient violence to produce unconsciousness and death, that laceration of the walls of the iter and floor of the fourth ventricle are constantly found, together with congestion of the pia mater, and disseminated extravasations of variable amount, and often minute punctiform hæmorrhages in the substance of the brain. The same symptoms were found to follow the sudden injection of fluid wax into the intracranial space through an opening in the skull. These results he explains in the following manner: The blow produces a depression of the skull at the point struck, and compression of the underlying brain. This compression drives the fluid in the lateral and third ventricles through the iter into the fourth ventricle, with force enough to lacerate the walls of the two latter; at the same time wave-like undulations are produced in the cerebro-spinal fluid, which reach their greatest intensity in the lacunæ at the base and about the medulla, so that here we usually find the largest amount of extravasation, and coincidently the perivascular spaces of the cortex are over-distended, the vessels which they contain compressed, and a corresponding anæmia of the brain-tissue produced. Following contraction of the arterioles, paralytic expansion follows with rupture and extravasation. The intensity of the result will depend upon the determining cause, and the symptoms which follow will depend upon the degree of anæmia, and the locality and extent of the lesions produced. The results of these experiments correspond so closely with what has been found following blows upon the head in man (Hewett), that the explanation given seems equally applicable; and although these observations of Duret have not been fully confirmed by Groeningen and Blumenstoch in similar experiments, we shall accept his conclusions, that: 1. A localized lesion, produced by the action of the cerebro-spinal fluid, is followed by symptoms depending on the functions of the part affected. 2. Immediately following concussion (choc) the symptoms depend upon the intensity of the lesion. (*a*) If the destruction of the part is complete, there is loss of function (paralysis); (*b*) if the lesion is slight, non-destructive, there is irritation and exaltation of function (spasm). 3. In case of any lesion there may be observed the phenomena of a diffusion of the symptoms, *i.e.*, epileptiform attacks, reflex contractions, etc.

Contusion of the brain may be either disseminated or localized. The rôle played by the cerebro-spinal fluid in the production of the first has been sufficiently dwelt upon in the above description. The localized form may occur immediately below the point of impact of the skull, or at a point diametrically opposite; in the latter the lesion being due to the brain being driven forcibly against its bony case. In slight cases of contusion, if seen before the occurrence of inflammatory changes, the injury is superficial and the area affected is of a purplish color, which is due to closely aggregated minute extravasations, and which gradually fades into the surrounding normal tissue. The consistency of the injured area is little, if at all, altered. In the severer forms there are larger extravasations and visible destruction of brain-tissue. Both forms of contusion may follow blows or falls on the head without the occurrence of fracture, and the natural elasticity of the skull is probably an efficient factor in their production. With the lesion of the brain-tissue itself more or less injury to the overlying membrane generally occurs, and there may be extravasations, usually circumscribed, in the pia mater, but more frequently there will be found hæmorrhage, often of considerable amount, in the cavity of the arachnoid, and less frequently between the bone and dura mater. In cases of depressed fracture pieces of bone may produce direct laceration of the brain and membranes. Limited fractures of this kind are much more apt to be compound than simple. In both simple and compound fractures of the vault, lines of fracture may extend to the base, lacerating the nerves as they pass through the bones, or wounding the membranes or brain-substance itself. In all of these cases there may be disseminated lesions due to the action of the cerebro-spinal fluid, and hæmorrhage of large extent may occur into the ventricles, due probably to the same cause. In cases of compound fracture there may be a loss of brain-tissue, and in certain fractures of the base cerebro-spinal fluid may escape for some time subsequent to the injury. Fractures of the petrous portion of the temporal bone, with laceration of tympanum or of the ethmoid, are most apt to be followed by this latter phenomenon. Again, the brain and membranes may be directly injured by foreign bodies penetrating the skull. These wounds may be either incised or punctured, or may be due to the passage of a bullet or some other foreign body. In such cases it sometimes happens that there is an entire absence of all evidence of general concussion

of the encephalic mass, though usually indications of a concomitant concussion are present. The amount of injury to the brain varies greatly in different cases. A bullet, for example, may remain lodged in the skull and press upon without wounding the brain, or it may be embedded in the cerebral tissue. Again, it may traverse the entire head, leaving a wound of exit, or passing through the brain it may lodge beneath the skull on the opposite side, or it may even rebound, penetrating the brain at an angle with its former course. Flourens has shown that bullets introduced beneath the vault in dogs tend to gravitate toward the base. A similar change of position probably can occur in man, and may account for some cases in which there is a sudden development of new symptoms without apparent cause. In many cases the bullet becomes encysted.

There are numerous histories on record of very extensive lacerations of the brain by the passage of foreign bodies without a fatal result following, and without any permanent impairment being left behind. In all of these cases more or less extensive disorganization of brain-tissue occurs, which necessarily gives rise to inflammatory action. This may be strictly circumscribed and only sufficient in intensity to remove or encapsulate the injured tissue, or it may result in yellow softening and in the formation of an abscess. Traumatic abscess, from any cause, may be either deep-seated or superficial, and the inflammation may extend to the membranes and result in the formation of adhesions overlying the seat of injury, or, what is of more frequent occurrence, may produce a general purulent effusion into the cavity of the arachnoid which will extend over an entire hemisphere, or, indeed, may pass to the opposite side. General purulent effusion into the cavity of the arachnoid is one of the most frequent and fatal of all the complications to which brain injuries are liable. In many cases entire restoration of the injured part seems to occur, if we can judge from the disappearance of the symptoms present for a time. In these cases the symptoms have probably been due to pressure from extravasated blood, which has subsequently been removed by absorption, though the possibility of the restoration of severed nerve-tracts must be admitted from the frequency with which union occurs in the peripheral nerves. In other cases the adhesions formed during the process of healing, especially when associated with depressed bone, or where there has been a loss of a portion of the skull, may produce ulterior effects, even where immediate recovery has taken place. These cases result in permanent impairment of the mind, or in the development of epileptic seizures, which usually tend to increase in frequency and severity, and which only yield to the removal of the depressed bone or irritating cicatrix which has been the efficient factor in their production. We must not, however, too hastily conclude that complete restoration has taken place because the symptoms do not persist. Hewett has reported a case, examined twenty years after a blow upon the forehead, followed by the symptoms of contusion at the time, in which there was a considerable depression at the tip of the frontal lobe, which was bridged over by the arachnoid, and filled by a quantityof cerebrospinal fluid.

Experiments in animals have clearly demonstrated that certain limited areas (centres) in the cortex control certain definite functions, and that destruction of these centres is followed by permanent abolition of function and loss of power in the corresponding part, while stimulation produces action confined and limited to the same part. The facts thus demonstrated by experiment are fully confirmed by clinical observation in man, and limited injuries to the brain are found to be constantly followed by paralysis of certain limited sets of muscles. The centres for the face, arm, and leg have been demonstrated to occupy the convolutions on either side of the fissure of Rolando, while the speech-centre is found in the base of the third frontal convolution. These centres are now generally admitted, and Ferrier further claims an oculo-motor centre just anterior to that of the leg, and a centre for vision situated in the angular gyrus. The facts of localization, as established, are of the utmost importance in considering the symptoms which follow injuries to the brain, for as limited lesions in certain regions are found to produce paralysis or spasm in certain limited sets of muscles, the occurrence of similar symptoms point to the location of the lesion on which they depend in those cases in which there is no visible injury to guide us.

In slight cases of concussion the symptoms are transient; there is more or less giddiness with some bewilderment, and possibly some staggering, with momentary loss of consciousness. The patient, if standing, may fall, but will usually at once be able to rise, and all of the symptoms promptly disappear, or may for a time leave some uncertainty of gait and slight obscurity in the intellectual functions. In grave cases the symptoms indicate profound shock. The patient is unconscious, the muscles relaxed, or certain sets of muscles may be firmly contracted, as in clenching the fists. The breathing is slow, catching, and irregular. The pulse is extremely feeble, is apt to be intermittent, and at times seems to have stopped altogether. The face exhibits extreme pallor, and the temperature may fall below normal. The pupils are either dilated or contracted, and are often unequal on the two sides, and contraction is often followed, after a short interval, by dilatation. During this period they either respond very sluggishly to light, or may fail entirely to do so.

In this state the patient may die. If improvement occurs it manifests itself first in the circulation, and the pulse becomes stronger, though the irregularity may remain. The face loses its pallor and becomes flushed. The eyes respond to light, the breathing becomes more regular, and is often sighing, and the patient manifests more or less restlessness by moving his limbs.

Paralysis, if it exist, can now be detected. Vomiting at this period is of frequent occurrence, and involuntary discharges from both bladder and rectum may occur, though retention of urine is more often observed. This seeming improvement may be only temporary, and all of the symptoms may again become more intensified; the patient sinks into profound coma and death follows. If the case pursues a favorable course, there is gradual improvement in all of the symptoms, the pulse and respiration become normal, and the patient is readily roused to answer questions and take nourishment, though when left to himself he will soon sink into a listless semi-conscious condition. This may assume the character of normal sleep, from which he may awake in some hours with the intellectual functions entirely restored; or a condition of partial consciousness may last for some days and only gradually pass off. This condition may be interrupted by the occurrence of delirium, either passive, in which the patient lies muttering to himself, or it may be of the more active kind, requiring restraint. These attacks of delirium are often associated with an increase of temperature, and indicate the extension of intracranial inflammation, or the occurrence of septic infection; indeed both of these conditions are often combined. During the state of partial consciousness and delirium, bladder and rectum may both be evacuated involuntarily, or the use of the catheter may be required habitually. The existence of paralysis during complete unconsciousness can only be surmised. When this has passed, even partially, away, complete hemiplegia may be found to exist, or monoplegia of arm, leg, or face, or a condition of aphasia or spasm may occur, limited to the affected muscles, or it may extend to others upon the same side. In rare cases muscles of the opposite side are attacked. These limited spasms may recur at short intervals, and continue for days, and then subside. During their occurrence the patient retains complete consciousness. Again, general convulsions, with complete loss of consciousness, may develop. They are always of serious import. Local paralysis, incomplete at first, may become complete, and may extend, and thus a monoplegia may become hemiplegia. Such extension indicates the supervention of inflammation, extending the area of the original lesion. The increase of the paralysis may be independent of any changes in the mental condition; usually, however,

it is the forerunner of coma and death. In other cases the paralysis persists without extending, and remains permanent; more often, however, improvement occurs, which either continues to complete cure or leaves some slight impairment behind. Paralysis of arm, leg, or face should always direct attention to the motor area of the opposite side, and even if injury to the skull is not apparent it is fair to conclude that local injury to the brain exists. This conclusion does not, however, justify too early operation for its relief, for monoplegia of even some days' standing may disappear. Fever, after injury to the brain, indicates the occurrence of intracranial inflammation, or it may be due to septic infection alone, or to a septo-encephalitis. It is of constant occurrence where diffuse arachnitis exists, and is here always followed by hemiplegia. When the injury to the brain is beyond the motor area no paralysis exists. Thus, in limited fracture of the frontal bone there may be no symptoms indicating any injury to the brain, even where there is marked depression of fragments and the development of a circumscribed abscess. If, however, this condition is not relieved by the elevation of the fragments and evacuation of the pus, evidence of compression usually occurs with more or less fever, and coma and death ensue. These symptoms often do not develop for some days, and then begin very insidiously. In fracture of the base involving the petrous portion of the temporal bone, cerebro-spinal fluid may continue to escape from the external auditory canal for some days. The same phenomena have been observed after fracture of the ethmoid. Where the pericranium remains unbroken after fracture, the gradual accumulation of fluid beneath it may form a meningo-encephalocele. In compound fracture of the vault there may be a loss of brain-tissue, and such fractures are often the occasion for the formation of hernia cerebri. These last cases usually, though not always, terminate fatally.

The intellectual faculties may be entirely unaffected after recovery from even severe brain injury, or the mind may remain more or less impaired. Such impairment will sometimes develop after a long interval, and finally lead to entire loss of reason. In other cases epileptic seizures develop. These are generally dependent upon some depression or thickening of bone at the seat of injury, or are the result of irritation from a cicatrix, or of pressure from a foreign body. The removal of the cause, even after the lapse of years, is often followed by the cessation of the unpleasant symptoms. Injury to the cerebral nerves is due either to rupture, laceration, or pressure from effused blood about them, or extravasation within their sheath. The symptoms due to loss of function in these cases may be either permanent or temporary; in the latter pressure has probably been relieved by absorption. The optic nerve, one or all of the branches of the third, the abducens, and the auditory nerves are the ones most often injured.

The diagnosis of the extent and character of a cerebral lesion is always obscure, even when fracture of the skull exists. Without visible external injury the location of the lesion in the brain must be determined by the facts of localization.

The prognosis of these injuries is always uncertain; trivial cases in the outset may become grave, and even fatal in the end, and apparent recovery may be followed by the renewal of dangerous symptoms or succeeded at a long interval by epilepsy, or more or less impairment of the mind.

The general indications for treatment are prevention of inflammatory complications, and to this end the removal of all present and possibly future sources of irritation. Depressed fragments of bone are to be removed, and the membranes and brain-substance itself incised for the escape of pus when it is apparent that an abscess has formed. In these cases, and wherever there has been destruction of brain-tissue, especially in gunshot wounds, thorough drainage is of the utmost importance. In gunshot wounds the ball should be removed, if possible, and in a limited number it has been traced through the brain and extracted by trephining the skull opposite the point of entrance. Monoplegia and monospasm, when they persist or tend to increase, are likewise indications for the use of the trephine over the appropriate region, even where no evidence of external injury is apparent. This rule is, however, by no means absolute, and even where there is evident injury (undepressed fracture) to the skull, with paralysis of the corresponding muscles, complete cure without operation may ensue. Recumbency, perfect quiet, and the avoidance of excitement must be enforced. Calomel in small doses, frequently repeated, seems to exercise a controlling influence upon the development of inflammation. For the periods of excitement chloral, bromide of potassium, and opium must be exhibited. During the depression following the first shock stimulants and the application of external warmth are indicated. In all cases the condition of the bladder requires frequent examination, lest retention pass unobserved. The occurrence of epilepsy justifies the removal of depressed bone or an irritable cicatrix, and the trephine is indicated even when at the seat of injury there is no evident depression, as thickening of bone may have occurred or a foreign body lodged beneath the skull.

N. P. Dandridge.

BRAIN, SOFTENING OF. The brain is said to be softened when its consistency is less than that taken as a normal standard. Diminution of consistence, however, shows but a part of the morbid work of an affection in which this phenomenon is only a circumstance quite accessory to the more important cerebromalacia, and the term in its literal acceptation could apply only to a diminution of the cohesion of the brain-tissues, while its other properties remained intact. Softening being a symptomatic word with a pathological meaning, like the word apoplexy, is rather a survival of a former belief, and its use is perhaps for this reason undesirable; but the name having been retained amid the fluctuations of opinions of writers on the subject, and in spite of its incongruity and the fact that it is often applied to cases in which there is really no softening, it is now employed to designate a necrobiotic process occurring in the elements of the brain-tissues consequent upon nutritive changes ordinarily attended by sensory, motor, and mental disturbances, which may vary according as the lesion is circumscribed or general in character.

Descriptions of the pathological changes accompanying occlusion of the cerebral arteries and the so-called encephalomalacia are comparatively new. Their discussion is limited to contemporary authors, who have definitely settled certain points involved in the development of a new subject, notwithstanding diversity of opinion touching the nature and character of softening.

In determining the question whether the diminished consistence or diffluence of cerebral substance be of pathological origin, two sources of deception should be guarded against; for this condition may be the result either of cadaveric decomposition or of accident happening during the extraction of the brain from the skull. The genuine morbid appearances are then to be distinguished from the artefacta produced by the investigator, and from the spontaneous changes occurring after death. Nor should the condition be confounded with diminished density or specific gravity. Normal white matter gives a specific gravity of 1.040, but when softened it is from six to eight degrees of the hydrometer scale lower than the normal condition; and the consistency of the brain is the same in individuals of all ages excepting the new-born and very young children. Season, temperature, and the disease to which the patient has succumbed, affect this consistence. An epileptic, dying during a paroxysm, in the month of June, by asphyxia from the penetration of food into the respiratory ways, has been known to present at the necropsy, twenty-four hours afterward, a completely diffluent encephalon. In a second instance, forty hours after death, with the same temperature, and in marasmus and an organic affection of the liver without cerebral symptoms, the brain was found to be in such a softened state that when it was placed on the hand the fingers penetrated by reason of its weight alone; while that of another cadaver, examined seventy hours after death and twenty-

four hours after the necropsy, was far from this state of softening.

Though most frequent in old age, softening spares no period of life, its occurrence having been noted in the new-born and even in the fœtus. That form peculiar to the senile condition appears to have served as a type in all the descriptions given by the best writers, who seem to have overlooked the pathological conformity shown in the failure of the nutrition as the primary and common cause of cerebral softening at the two extremes of life. In the new-born the profound disturbance of nutrition which, through the intermediary of the blood, disintegrates an organ whose softness has not yet been effaced by age, is essentially the same as that which in the senile state prepares for arterial and cardiac lesions, the formation of embolism or thrombosis, and the consequent incomplete irrigation of the cerebral substance by the blood. This starvation of the brain consequent upon diminished supply of arterial blood is now spoken of as necrobiotic and non-inflammatory in its nature. Such terms, however, as cerebral infarction and necrobiosis, though establishing facts, do not explain the phenomena of cerebral disintegration.

Certain observers recognize in brain-softening inflammation of an absolute kind; some regard it as a morbid state analogous to senile gangrene; others see a vital lesion affecting the nutritive integrity of the brain; while others consider it as a lesion of nutrition owing to local ischæmia, provoked by arrest or diminution of circulation either in one of the cerebral arteries or in the capillaries of the brain.

This profound trouble of nutrition, the essence of which is unknown, may occur as a primitive necrobiosis of the brain substance, or this necrobiosis may be preceded by a vascular lesion that causes a want of supply of blood effected through embolism, the local formation of a thrombus, or by compression of the vessels. If a cerebral vessel be stopped, that part of the brain supplied by the vessel is suddenly deprived of nourishment, and this will be definitely the case if the embolism remains in place. When the vessel in question is a terminal artery, which does not exchange blood with other arteries, there will be immediate stoppage of cerebral function, followed by rapid changes into fat of the brain element, and eventually into the liquescent state.

The anatomical characters and circumstances that preside at the evolution of cerebral softening have been fairly made out. Observations in this direction warrant the statement that the *arteria fossæ Sylvii sinistræ* is most exposed to embolic occlusion, which circumstance may be explained anatomically by the difference in the angles at which the left carotid and the innominate arteries are given off by the aorta. For this reason the left carotid is liable to catch an embolus coming from the heart, and the left Sylvian artery being the terminal artery in question, the regions provided by this vessel are consequently most in danger of being affected by the embolic process. These regions are the nucleus lenticularis, the terminal nuclei in part, the external capsule, and part of the internal capsule. The terminal branches of this vessel supply the second and third frontal convolutions, the island of Reil, and proximal surroundings, these being the portions of the brain most likely to suffer from the necrobiotic process. Further anatomical changes in the cerebral substance may result from the formation of an autochthonous coagulation, in consequence of degeneration of the intracranial vessels. Circumstances favoring the rapid formation of the thrombus are diminished motor force of the heart, roughening of the inner walls, narrowing, and loss of force and elasticity of the vessels. Tumors of rapid growth, and inflammatory processes and their surroundings, which compress the vessels to such an extent as to lead to softening, are phenomena often observed in connection with softening. Occasionally the affected vessel is discovered entirely empty at the post-mortem examination, and for this reason it is supposed that the occluding mass has been reabsorbed.

The first fact of importance in connection with the pathological details of softening, is the infrequency of anatomical changes in the cerebral substance when the seat of obstruction is on the cardiac side of the circle of Willis, which permits the prompt re-establishment of the circulation on account of its free anastomosis. If, however, the embolus is lodged in one of the terminal arteries of the basal arterial system, and a large region be thereby deprived of the necessary supply of fresh blood, there will be flowing back from the veins, and the tissues will become hyperæmic and œdematous, and filled with small extravasations known as hæmorrhagic infarctions In this simple necrobiotic change, the blood and coloring matter pass through the ordinary metamorphosis, the tissue of the brain swells and decays, leading to the rapid development of masses of granular cells, and finally to fatty emulsion. Later the diseased focus may become reabsorbed and a cyst remain in the place of the softening, but this is rare; in fact, such a result may never occur except in the case of a small focus of inflammation The process is more often followed by red sanguineous infiltration and yellow softening. Sanguineous infiltration is, however, not always present, and yellow softening is sometimes observed without its presence.

Although the etiology of the large group of clinical symptoms popularly known as brain-softening touches one of the most delicate points of medicine, but little satisfactory is to be said regarding its remote causes. Among those which predispose more or less are old age (from fifty to eighty) or agedness, chronic alcoholism, syphilis, sexual excesses and fast life, Bright's disease, acute rheumatism, the dartrous diathesis, chorea, scarlet fever, insolation, intense cold, intense and long-continued intellectual exertion, severe and protracted emotional disturbance, misery, fright, overwork and responsibility, the abuse of opium, menstrual troubles, and, according to some authorities, the puerperal state. The cachexias, and the inopectic diathesis (that is, a tendency to embolism, to thrombosis, and to coagulation of fibrine), are adjuvant causes, the importance of which should not be overlooked. Among negroes, the intertropical races, and the inferior races generally, softening and other forms of brain disease are infrequent, and the aptitude for such disease grows with the degree of perfection of the species. Women are less subject than men, principally for the reason that, being women, they do not undergo the strain and exhaustion of high brain energy and severe muscular labor, and are not so exposed as men to the poison and excitement of alcohol, syphilis, and tobacco.

Brain-softening is the pathological sequence of many different conditions; but the more important causes that bring about the results in question may be stated as follows, when brought concisely together: Endocarditis, through the production of movable products; myocarditis, through the formation of thrombosis in the heart; all processes in the lungs leading to coagulation or to the reception of septic material into the veins of the lungs; aneurism of the aortic arch; atheroma of the cerebral arteries; tumors of the brain, and even encephalitic foci; syphilis of the brain; the accumulation of pigment and pigmentous flakes in the blood, in connection with severe cases of malarial intermittent fever; and capillary occlusion through drops of fat. Other sources are injuries and inflammations of the bone, the occlusion brought about by pus-cells or white corpuscles, and the blocking of the vessels by lime metastasis.

Of the phenomena of the occlusion of the intracranial vessels usually preceding the encephalomalacia, it is impossible to present a clinical picture in definite terms without going into the details of embolism, thrombosis, and hæmorrhage, for full particulars of which the reader is referred to their respective headings. Although spoken of in the same connection, cerebral softening and occlusion of the cerebral vessels are not necessarily interdependent, since softening does not always follow occlusion, and for this reason there is a tendency among some to consider softening as a distinct pathological condition.

Softening of embolic origin always begins by the symptoms peculiar to encephalic effusion of blood, or to those of apoplexy, the word being taken in its traditional sense. In fact, the symptoms are so similar to each other that

their differentiation may be a matter of great difficulty to the most experienced. The symptoms that characterize the early period of embolism are sudden. Without premonition the patient is seized with a sudden dizziness, or a momentary headache, and with an involuntary cry falls consciousless; motion and sensation appear to be extinguished, and unilateral paralysis, generally of the right side, follows. The only apparent difference between the symptoms occasioned by embolism of a cerebral artery and those of hæmorrhage, is the more transient state of the unconsciousness. For this reason part of the symptoms are often spoken of as apoplectic. In some cases, where the symptoms are less distinct, the unilateral paralysis forms a prominent feature. Other cases are prominently marked by more or less dizziness, by the absence of coma, by convulsions, and by unilateral symptoms. This seems chiefly the case when embolism occurs in a circumscribed smaller cortical region, or when the embolus is reabsorbed and the circulation restored. Vomiting sometimes attends the onset of the attack; at other times delirium of a transitory character occurs, and in many cases sudden aphasia results from the anæmia produced in the speech-centre by the embolic occlusion of the artery supplying that region. There seems to be diversity of opinion among observers regarding the state of the pupils during the onset of the attack; it is probable, however, that they vary in different cases. At the fundus of the eye there may be found papillary or retinal œdema. It is only in chronic senile cases that papillary atrophy occurs.

Thrombosis of the cerebral vessels is usually attended by premonitory symptoms, as persistent headache, either diffused or localized, slight dizziness, a sense of general confusion, unilateral disturbances of sensation, and even violent transient paresis. Further development of the trouble gives rise to excitement and active delirium, causing the patient to get out of bed at night and to commit other unreasonable acts. Symptoms of depression may follow this period of excitement, the patient becoming apathetic and answering questions with difficulty. His movements are slow; there is tendency to somnolency; and a notable decrease occurs in the psychic functions, this decrease being characterized mainly by failures of the reasoning process, and by a more or less compromised memory, both of which are shown in verbal amnesia and other dysphasic affections. The humor is changing and emotional, and later the mental and other symptoms may become those of localized cerebral disease generally. As the patient goes into greater decline there may be decubitus, and he may die from bed-sores; from an intercurrent malady, as a cardiac, renal, or splenic complication, or a pulmonary phlegmasia; from a new attack, or from some new lesion of the encephalon. Generally the patient dies in a state of profound adynamia. The size and physiological importance of the occluded vessels determine the difference in the extent and duration of the symptoms. In fresh and vigorous subjects the occlusion of a small vessel may be followed by recovery, if the collateral circulation be established before the stage of necrobiosis begins. However, in most cases of autochthonous thrombosis that survive, the subsequent history is that of chronic localized brain disease, and of the motor, sensory, and intellectual disturbances that follow. The same may be said of embolic softening. Actual softening being fully established, the most prominent symptoms are permanent weakness, often persistent hemiplegia accompanied by athetoid spasms, and progressive mental weakness ending in paretic dementia. With the exception of the disturbances of vision, the affections of the special senses are the same as those that occur in connection with cerebral hæmorrhage. The same is true of the sensory, trophic, and vaso-motor disturbances. Sudden amaurosis from occlusion of the arteria centralis retinæ has been observed to occur in some cases of embolism. Anæmia of the fundus has also been found; and certain observers attach much diagnostic importance to the arterial and venous hyperæmia of the retinal vessels and to congestion of the optic disk.

The paralyzed limbs are generally those of the right side, for the simple reason that the left Sylvian artery is oftener occluded than the right. Bilateral paralysis may, however, follow bilateral vascular occlusion. Since we are unable to offer any satisfactory explanation of either the presence or the absence of contractures of the paralyzed limbs, they can scarcely be regarded as of pathognomonic significance. Motor restlessness, though characteristic of the worst cases, is greatly influenced by heredity. A patient of bad nervous antecedents, with a spot of progressive softening in one of the corpora striata, may become noisy and restless and suffer from insomnia, while another, with no nervous heredity and under the same conditions, is quiet and manageable. As enfeeblement progresses the motor symptoms are particularly noticeable in the paretic walk and aphasic speech, the latter resulting from a disturbance of the secondary co-ordination consequent upon a lesion of the basal motor-ganglia (see Aphasia).

A brain affected by softening being on the verge of dissolution, the most prominent and troublesome symptom is the disturbance of the mental functions. The faculty most prone to fail is memory. The vesicular neurine not being susceptible to the impression of events, the patient is unable to recall recent experiences and impressions with distinctness. The destructive metamorphosis of the convolutional structure is further shown in the impairment of the reflective faculty or power of judgment; and as the cerebromalacia progresses the patient may become whimsical and peevish, or his affective power may be deadened, and the intellectual faculties may decline into childishness and finally become extinct.

The occurrence of these mental changes in connection with the situation of the brain lesion may be further studied under other headings (see Brain, Diagnosis of Local Lesions in, and Cerebral Cortex, Functions of the).

The diagnosis of cerebral softening should be based upon the history of the case and the proving of such fundamental conditions as may produce hæmorrhage and embolism or thrombosis. Hæmorrhage cannot be distinguished from thrombosis by any absolute means, notwithstanding the various diagnostic signs that have been proposed at various times; but the condition of softening may be established with a probability bordering on certainty when the associated symptoms are taken into account. When the premonitory symptoms have continued for a long time, the so-called apoplectic accidents point to cerebral hæmorrhage rather than to embolism; but the symptoms in all probability may be owing to thrombosis. Gradual march of the paralysis indicates thrombosis rather than cerebral hæmorrhage. The rapid appearance or disappearance of the attack, and the situation of a centre of softening in the left hemisphere point rather to embolism than to thrombosis. It can also be affirmed with almost entire certainty that the encephalic foyer is of embolic origin when the presence of the symptoms permits us to suspect the formation of splenic or of renal infarction. Such symptoms would be likely to occur after a sudden attack in a young subject with an active *bruit de souffle* and enlargement of the spleen, pains in the lumbar region, and the presence of blood in the urine. Cerebral softening may be confounded with encephalitis, with hæmatoma of the dura mater, and with tumors. In tumors the speech and intellect are generally unaffected, and there is pain with convulsions, vomiting, double optic neuritis, and choked disk; in hæmatoma the history of the case is the main reliance in making out a correct diagnosis; while in encephalitis there is a considerable rise in temperature, and the evidence of tissue action in the respective region of the brain, which is notably absent in softening. The signs of arterial atheroma are of no value.

Softening of the brain, more or less grave according to the extent and intensity of the functional troubles, is a disease that ends in death after a certain time, varying from a few days to several months or years. More die of the acute than of the chronic form. Some think the malady curable, but it leaves ineffaceable marks in the

most favorable cases, and the reported recoveries are to be looked upon with a great deal of doubt. They are said to have occurred in young and vigorous subjects; and when it is taken into consideration that the symptoms may have been incorrectly observed, or that they may have been those following various depraved states of the nervous system, the statement becomes more problematical. When not carried off by the initial symptoms, the patient is left with an incurable infirmity, in one of the most unfavorable conditions known. With the gradual enfeeblement of the intellect he is constantly threatened with new symptoms, and the reproduction of the original causes that produced the centre of softening. In fact, these causes greatly influence any forecast that it is possible to make concerning the march and duration of the malady. As a rule, it may be said that the indications are the more favorable in simple circumscribed embolism, and most unfavorable in cases of autochthonous thrombosis. The prognosis is worse when there is slight impairment of the intellect, sensibility, and motility taken together than it is when any one of these singly is profoundly impaired. A case may be regarded as hopeless as long as the underlying cause of the attack remains, and extreme gravity is to be attached to such symptoms as rise of temperature and bed-sores.

The causes that produce softening are difficult to remove and the therapeutical treatment of their effects is generally barren in results, notwithstanding correctness of diagnosis and the most judicious efforts to meet symptoms as they occur. Preventive measures being out of the question, except when the premonitory symptoms have continued for a long time, a consideration of the causes becomes a fundamental matter, and the state of the heart and its action the main question. A declivous position of the head and perfect rest in a uniform temperature are advisable during an acute attack, while the body should be kept warm by artificial heat, warm clothing, and the cautious administration of stimulants. The caution in regard to stimulation is the more to be observed if there be the least suspicion of hæmorrhage. In such a contingency it is deemed wise to act as if the case were one of cerebral hæmorrhage, since hæmorrhage is more likely to occur than occlusion, and the harm following stimulation in such a case would seem to justify the diagnostic doubt. Symptoms pointing to a severe collateral hyperæmia may be treated with large doses of the bromides, sinapisms, dry cupping, and mild purgation. The actual cautery and bleeding are to be avoided; but when there is general vascular irritation, leeches may be applied to the anus and behind the ears, in connection with intestinal revulsives and cold applications to the head. The use of digitalis is indicated if the arterial tension be weak; its use is, however, inadvisable in old persons. Recourse may be had to nervine tonics and to mild forms of slow derivation after the attack has passed. The diet should be strictly regulated, all intellectual effort should be interdicted, the integrity of the nutritive functions should be maintained as much as possible, and the methods of treatment applicable to the chronic symptoms of circumscribed cerebral disease should be generally observed. *Irving C. Rosse*

BRAIN, SYPHILITIC DISEASES OF. Under this head the syphilitic diseases of the brain, of the cerebral meninges, and of the cranium will be considered.

History.—Professional opinion is at variance as to the date at which syphilis first appeared among mankind. Some writers contend that it is comparatively a new disease, and first attacked man in the fifteenth century. Other authorities believe that the disease is coeval with the human race. Others, not subscribing to this latter opinion, affirm that it prevailed in China long prior to the Christian era.

No such difference of opinion exists as to the date at which the syphilitic diseases of the nervous system were first recognized. By universal agreement the time at which this class of diseases began to attract attention has been fixed at the beginning of the present century. Anything like accurate information on this subject did not exist even half a century ago. It is true that some few of the early writers on venereal diseases state that epilepsy, paralysis, apoplexy, etc., had been observed by them in the course of syphilis, but the history of the cases reported was vague and indefinite, and the views of these writers were formed independently of pathological demonstrations, and failed to command professional assent. Even John Hunter and Sir Astley Cooper denied that syphilis attacked the nervous system, and this was the professional opinion prevalent at the beginning of the nineteenth century. It is only within the past forty years that clinical observation and pathological research have furnished data sufficient for the building of this department of medicine into a science.

In a limited article it is, of course, impossible to trace the history of this subject, and to do justice to the labors of the vast number of physicians who have patiently and assiduously cultivated this field. Suffice it to say, briefly, that in France Lallemand and Rayer especially distinguished themselves, and were among the pioneers in observing the clinical history and examining the pathological anatomy of this class of diseases. Schutzenberger, among the physicians of Germany, is entitled to like credit. From the long list of those who have added to the exacter knowledge of syphilitic diseases of the nervous system the following-named physicians are entitled to especial mention. They are: Lancereaux, Gros, Zambaco, Ricord, Jaksch, Braus, Dietrich, Pidoux, Trousseau, Yvaren, Fournier, Virchow, Heubner, Hutchinson, Broadbent, Hughlings Jackson, Todd, Echeverria, Reed, Moxon, Buzzard, Wilks, Cornil, Dowse, and Allbutt. The literature upon this especial subject is voluminous, and evidences the fact that no department of syphilography has, within the past fifteen years, been so patiently and exhaustively investigated as that of syphilitic nervous diseases. These diseases are now known to be of frequent occurrence, and may be diagnosticated with as much certainty as any other class of nervous diseases, and the treatment of them is often followed by marvellous results.

Etiology.—The immediate cause of this class of affections is the existence of constitutional syphilis in the system of the individual.

The predisposing causes are, mainly, inefficient treatment of the primary or secondary stages of syphilis, mental strain, sexual excesses, alcoholic intemperance, depressing emotions, cachexia, gout, sunstroke, and mechanical injuries of the head.

Syphilitic diseases of the brain originate in lesions of one or more of the following structures:

1. The skull.
2. The dura mater, arachnoid, or pia mater.
3. The brain.
4. The arteries.

The membranes, brain, or cranial nerves may be affected in consequence of either of the following lesions:

1. Syphilitic nodes, gummata, or necrosis of the cranium; or growths in the endosteal linings through which the nerves course prior to their exit from the skull.
2. Syphilitic inflammation or growths in one or more of the membranes of the brain.
3. Growths connected with the brain substance.
4. Changes in the arteries of the brain, eventuating in narrowing, occlusion, or rupture of the artery, with consequent atrophy or softening of the brain.

Osseous Affections.—Any lesion located on the inner surface of the cranium can develop inflammation of one or all of the membranes of the brain, and may be causative of diseased processes of the brain substance. Nodes, exostoses, caries, and necrosis constitute the principal syphilitic affections of the skull. Generally speaking, nodes of the cranium are met with in the tertiary period of syphilis, though they have been known to be developed on the outer table of the skull within a few months after the chancre first appeared. It may, therefore, be affirmed that nodes of the inner table may occasionally be found within a few months subsequent to the primary affection, or either of these lesions may appear

as late as twenty or even forty years after the chancre. They are causative of serious affections of the meninges and of the brain, which arise from an extension of the inflammation therein, or from pressure of growths thereon, upon the brain and its coverings, these latter lesions being secondary to the osseous affection. Finally, thickening of the periosteum, or other osseous growths around any foramen through which a cranial nerve finds exit from the skull, may impair or destroy the function of the nerve so endangered.

MENINGES. — The syphilitic lesions of the meninges are:

Pachymeningitis.—The dura mater is, of all the membranes of the brain, most liable to attacks of syphilitic inflammation. The inflammation is circumscribed in the form of gummata, or a fibrous thickening of portions of the membrane may occur. The product of these changes is usually found to be a yellow, lymph-like substance which, when developed on the inner surface of the dura mater, causes a coalescence of that membrane with the arachnoid, pia mater, and brain; if it be developed on the outer surface of the dura mater the inner table of the skull may be secondarily involved. The dura mater is occasionally found to be the only one of the meninges affected.

GUMMATOUS GROWTHS.— Gummata of the meninges will be more frequently encountered than any other syphilitic lesion of the brain or its coverings. They will be found dispersed as nodules, of a cheese-like consistency, between the meninges, or surrounded by hardened patches of pachymeningitis, or as distinct tumors of large or small size on the outer surface of the dura mater, or between the several meninges.

SYPHILITIC AFFECTIONS OF THE CEREBRAL ARTERIES. —Exact knowledge on this subject really dates from the publication of Heubner's monograph in relation thereto. The following is transcribed from Heubner, on "Cerebral Syphilis" ("Ziemssen's Cyclopædia," vol. xii., pp. 309, 310). "In addition to the atheromatous process which sometimes affects the vessels of syphilitic patients, the arteries at the base of the brain are subject to a peculiar form of disease, sometimes when a syphilitic growth is developed around them, but sometimes entirely independent thereof.

"As the disease begins the blood-vessels become less transparent, their reddish color gets a whitish glimmer, and finally becomes completely grayish-white; they lose their usual shape of a flattened cylinder, and become completely round; they are firmer to the touch, and at last perfectly stiff and hard as cartilage. Upon section we may remark, even with the naked eye, that the lumen of these vessels has been more or less encroached upon; at first by semilunar segments, and later by zones of new-formed substance lying around the periphery. This substance is of a white or gray color; at first moist, afterward more dry, of a tough, in the later stages hard and cartilaginous, consistency. The calibre of the vessel is thus reduced to one-third, one-fourth, or one-fifth of its original dimensions, and, at last, places may be found where the remaining passage is stopped by an adherent thrombus, or where there is no passage at all, but the whole artery is changed into a solid cylinder. In such cases the whole arterial system at the base of the brain exhibits a general narrowing.

"This growth is developed between the elastic lamina of the intima (membrana fenestrata) and the endothelium, and consists at first of endothelial cells, which constantly increase and change into a firm, felted connective-tissue, composed of spindle and stellate cells, into which the emigration of round cells from the vasa nutrientia of the vessels takes place, so that a granulation tissue is formed like that of syphiloma in other places. The new tissue grows often in distinct periods in two directions, toward the interior of the artery and in the direction of its length; and thus, on the one hand, gradually narrows the starting-point, and, on the other, involves in the degeneration more and more of the main artery, with the communicating vessels and branches, even to those of small dimensions.

"In its further course the new growth either becomes organized—taking a similar structure to that of the original wall of the vessel, and the process comes to a standstill after great diminution of the vascular calibre;—or cicatrization occurs after complete obliteration, with transformation into fibrous connective-tissue, and the whole portion of the artery affected becomes useless.

"By this process a more or less extensive portion of the channels by which blood is carried to the brain is rendered materially less capable of its normal action, and functional disturbances of the brain substance arise; or when, either by the new-growth itself or by an added thrombus, such portions of the vessels as give rise to terminal arteries are obliterated, softening of the brain takes place. This degeneration most frequently affects the carotids and their branches, the arteries of the fossa Sylvii and of the corpus callosum near their origins. But it is exactly these portions from which the terminal arteries, supplying the nucleus lenticularis and nucleus caudatus, arise; and hence the frequent softening in these regions."

The syphilitic lesions of the brain are:

1. Gummata.
2. Softening.

Cerebral gummata are of two forms.

(*a*) Large gummatous growths located upon the surface of the brain, or within the convolutions, the gray or white substance. They are generally multiple, and vary in size. Occasionally these growths are located upon the cerebellum.

(*b*) The second form of these gummata is that of small nodules, accompanying the cerebral arteries, especially the middle cerebral.

Both forms from a histological point differ but slightly in structure, but vary somewhat in development. The second form is usually associated with endarteritis, which often leads to anæmic softening of the brain.

Cornil says of these growths: The cerebral gumma is, therefore, characterized by two zones. One peripheral, in which are found nerve-fibres, reticulated tissue, swollen and sometimes branching cells of the neuroglia, and a great abundance of small cells among the preceding elements and in the perivascular lymphatic sheaths; the other central, in which the numerous cells of new formation, crowded one against the other and compressing the vessels, have destroyed all the elements of the nervous tissue, and are themselves undergoing a granulo-fatty atrophy. The diagnosis of gummata of the central nervous tissue may be made by their known characteristics as revealed both to the naked eye and under the microscope. They are tumors or neoplasms formed in the normal tissue, with which they incorporate themselves, and which they partially destroy in their process of formation.

SOFTENING OF THE BRAIN.—This affection is almost invariably secondary to lesions of the cranium, the membranes, or the vascular system. The softening is usually limited to the area of the brain compressed by growths, or deprived of blood-supply. Softening due to loss of blood-supply may be limited to a short portion of a single artery and the area supplied thereby.

The following are the syphilitic diseases of the brain:

EPILEPSY.—Epilepsy is frequently encountered in the course of cerebral syphilis. It is always, so far as yet known, the result of a material lesion, which is usually located at the surface of one of the cerebral hemispheres. It may be caused by tumors growing from the internal surface of the cranial bones, or from the dura mater or pia mater, or from the substance of the hemispheres reaching the surface, or by diffuse exudation between the membranes, or by thrombosis of cerebral vessels. The most usual cause of syphilitic epilepsy is a gummatous tumor in the pia mater on the convexity of one of the cerebral hemispheres. It may be limited and superficial, or it may involve the cortex to a greater or less extent. Of twenty-six cases of gummatous tumors on the surface of the brain, observed by Heubner, twenty were attended with convulsions; while in nineteen other cases, where

the morbid process was located in the white substance or base of the brain, convulsions were observed in only two cases. Hughlings Jackson, Wilks, Jaksch, and others have had a like experience. Syphilitic epilepsy is generally observed in the tertiary period of syphilis, though it has occasionally been seen within a few months of the primary affection. The convulsive phenomena may be the only prominent sign of cerebral syphilis, or they may be the forerunners of more serious lesions, or may be associated with other grave affections. The convulsions are usually unilateral and vary in degree from the slightest to the severest manifestations. Convulsive manifestations may be limited to the face, arm, leg, or side, and in rare instances, both sides of the body may be convulsed. Hughlings Jackson's experience is that when the convulsive movements of partial epilepsy, commencing in the arm, tend to become more general, they attack the face before they extend to the leg. If the irregular movements have commenced in the face, the disease extends to the upper extremity first, and then to the leg. Lastly, if it be the lower extremity which is first attacked, the disorder of motor power is seen in the arm first, and then in the face. This constancy in the order of succession is very marked. Complete loss of consciousness is extremely rare in syphilitic epilepsy. In the cases observed by me I have never seen one in which consciousness was not retained to some extent.

Differential Diagnosis.—1. Age is an important point in diagnosis. In simple epilepsy the attacks usually commence before the individual is thirty years of age—most frequently between the ages of ten and twenty years, and next between two and ten years of age. In the syphilitic variety the attacks are generally observed after the patient has reached thirty years. Of course this varies with the age of the individual at the time of contracting the primary infection. In children, the subjects of hereditary syphilis, convulsions may be observed before the subject is one year old. In thirteen cases observed by Drs. Gros and Lancereaux, syphilitic epilepsy commenced ten times near the age of thirty and three times in persons between the ages of fifteen and sixteen. Of these latter individuals one contracted syphilis at seven years old, and the other two at fourteen. Jaksch collated the records of forty-three cases of syphilitic epilepsy, and found that the ages of thirty-one of the individuals were from thirty to forty years, eleven from forty to fifty, and only one was as young as twenty years. Dowse, from an examination of the records of two hundred and seventy-four cases, found that the patients in the majority of instances were from thirty to forty years old. Fournier, Gowers, and other writers have had a like experience.

2. Cephalalgia. In syphilitic epilepsy there has usually been persistent cephalalgia for days, weeks, or months prior to the epileptic seizure, and the pain generally continues between the attacks. In the simple variety the vast majority of patients have had no prodromal symptoms—the onset of the attack was sudden, and the subsequent cephalalgia of short duration.

3. Loss of consciousness is rarely absent in the simple variety, and seldom observed in syphilitic epilepsy.

4. Recurrences of convulsions are usually infrequent in the simple, and frequent in the syphilitic variety.

5. Mental derangements between the epileptic seizures, are, as a rule, persistent in syphilitic epilepsy. They are of various proportions—in some instances being with difficulty detected. Unrelieved by treatment, these derangements are progressive. In the simple variety mental disturbances rarely persist beyond a few hours.

6. Optic neuritis is frequently associated with specific epilepsy, and is absent in the simple. Optic neuritis, it should be remembered, may be caused by non-syphilitic tumors of the brain.

7. Paralytic phenomena often precede, accompany, or follow the convulsive seizures in syphilitic epilepsy. They are absent in simple epilepsy.

8. Unilateral spasm is the rule in syphilitic epilepsy, general spasm in the non-syphilitic.

9. History of previous syphilitic infection, or manifestations of constitutional syphilis on the body of the patient.

10. Results of treatment. Marked diminution of symptoms during a course of anti-syphilitic treatment is presumptive evidence of the syphilitic nature of the disease.

In considering these diagnostic points, it must be remembered that by no one symptom can syphilitic epilepsy be diagnosticated. Any one of them, taken by itself, only indicates some lesion affecting parts of the motor or sensory tracts. The concurrence of several or all of the above-named signs will be necessary to enable the physician to arrive at a positive diagnosis.

The following is a brief epitome of the governing principles by which syphilitic tumors of the brain may be diagnosticated from those which are non-syphilitic. The tumors of this region most frequently encountered are the following:

1. Tubercular growths. These are usually observed at an early age, and are attended by fever and a tuberculous history, or tuberculosis will be found in some other part of the body.

2. Cancer of the brain is indicated when the patient is forty-five years of age or more, and when there is an hereditary tendency to cancer, or when a cancer exists in any other portion of the body, or when marked cachexia with continued emaciation of the body accompanies the cerebral affection.

3. Gliomata result from traumatic injuries of the cranium. The progress of these tumors is slow, and they rarely interfere with the general health.

4. Syphilomata are usually accompanied by nocturnal cephalalgia, by symptoms of constitutional syphilis, or the evidences of previous syphilitic infection. Mydriasis and ptosis are more frequently met with in syphilitic tumors of the brain than with any other cerebral tumor. The symptoms of specific tumors often remit from time to time, and when attacked with anti-syphilitic remedies in the early stages they rarely persist for any great length of time.

Syphilitic Paralyses.—These are among the most frequent and serious results of syphilitic diseases of the brain. Of 100 cases of cerebral syphilis reported by Braus, it was shown that paralysis occurred in 83. They were as follows: Paralysis of the ocular muscles, 34; of the face, 27; of tongue, 22; of bladder, 17; of intestines, 15; hemiplegia, 31; of one limb, 18; paraplegia, 8. Such paralyses are occasionally incomplete and transient, others complete and permanent. The relief of these phenomena depends upon the retrogression or resorption of neoplasms in the membranes, the neuroglia, the arteries, or the cranial bones. Where multiple paralyses are observed gummata will generally be found at the base of the brain, or chronic basilar meningitis, with constriction of cranial nerves due to shrinking of the exudation, or syphilitic endarteritis of the basilar or vertebral arteries.

Syphilitic Hemiplegia.—Of the several syphilitic diseases of the brain, this is one of the most frequent. According to Rosenthal it occurs in about one-third of the individuals affected with brain syphilis. It may be caused by a gummatous tumor pressing upon the motor tract, or located upon the surface of the cerebral hemispheres, or the tumor may, by pressure upon an artery, produce obstruction of cerebral circulation, with subsequent degenerative changes in the brain-substance; or the disease may occur in consequence of syphilitic arteritis—which has been so graphically described by Heubner. The prodromal manifestations are usually cephalalgia, sleeplessness, vertigo, mental disturbances, convulsions, etc. Hemiplegia is often developed gradually. After several or all of the above-named prodromal symptoms have shown themselves for a greater or less period of time, the patient discovers paralysis of one or more of the cerebral nerves, manifested by squinting, impairment of vision, diplopia, ptosis, etc., followed by paralysis or impairment of motion in the arm, leg, or side of the body. In this form of paralysis the lesion will generally be found at the base of the brain—the rule, as stated by Broadbent, being that paralysis of the limbs and cra-

nial nerves, gradual in development, is characteristic of lesions located at the base of the brain. In this form loss of consciousness is rare, except in those cases which have not been promptly treated.

In other cases of hemiplegia the patient is struck down suddenly in the midst of apparent health, the apoplectic seizure being the first sign observed. This sudden attack is at times accompanied by alarming symptoms, such as weak pulse, cold extremities, slow and stertorous breathing, etc. The stupor may continue for several months before improvement is observed. The patient is in a typhoid-like condition. He can be roused only by persistent effort, and, if undisturbed, he rapidly sinks into insensibility, or there may be more or less restless activity of body, associated with purposeless impulses. He often attempts to leave his bed, but may be unable to stand or walk. If asked what he is doing or where he is attempting to go, his answer will demonstrate that he does not know. Fæcal evacuations are made in the bed, or on the floor, the patient thinking he is over a vessel. If asked any question he seems dazed, and answers in a hesitant, incoherent manner. Impairment of memory is especially noticeable. He will generally drink whatever is proffered him, though he rarely asks for food. During any act he readily sinks into sleep, which requires much effort to arouse him from. Sensibility in the paralyzed limb or limbs is preserved to some extent, as will be made manifest by pricking with a pin. There may not be actual paralysis, the impairment of motion being only partial. As a rule these sudden paralytic attacks are due to arterial lesions, with or without morbid affections of brain-substance. Upon regaining consciousness the patient will find that he is paralyzed in the arm, leg, or one side of the body, often associated with aphasia. In these cases restoration to health is gradual; full recovery of mental and physical health is seldom observed. Mental disorders often persist where apparent restoration of physical vigor is shown. The memory is impaired, or the former readiness of mental perception or fluency of speech is absent. The disturbances of locomotion usually continue for lengthened periods of time, as evidenced by dragging of the foot or helplessness of the arm; the patient being unable to walk unless the use of a stick is called to his aid. Where hemiplegia was complete, and improvement commences, the use of the leg is generally restored before that of the arm. In many cases in which the full use of the leg is recovered the paralysis of the arm is permanent. Paralysis of cranial nerves is marked by a like protracted duration, and while recovery is the rule, permanent loss of function is by no means infrequent. In cases in which all paralytic phenomena disappear and full health is apparently recovered, the patients are liable to recurrences of these attacks. The physician should, therefore, be cautious in promising permanent relief. If the morbid process is located in the arteries of the brain the prognosis is unfavorable. Treatment may remove more or less of the new growths in or around the arteries, and thereby effect a restoration, complete or partial, of the circulation, yet disorganization of arteries or of brain substance can never be remedied by any treatment, no matter how judicious or prolonged. In these latter instances impairment of mind is inevitable, the impairment being governed only by the seat and extent of the lesion.

Diagnosis.—There are several points in diagnosis of syphilitic hemiplegia. They are:

1. Age. Hemiplegia occurring in an individual from twenty to forty-five years old, and which is not connected with mechanical injury, embolism of brain consequent upon heart disease, or Bright's disease, may with reasonable certainty be claimed to be of syphilitic origin. In nineteen out of every twenty such cases this proposition will be verified.

2. The simultaneous occurrence of paralysis of two or more portions of the nervous system, not necessarily connected, is frequently observed in brain syphilis, and is rarely seen except as the result of this disease.

3. The co-existence of cachexia which cannot be traced to constitutional diseases other than syphilis.

4. The history of a former attack of syphilis. The infection may have occurred from two to thirty years preceding the hemiplegia. Upon this point it must be remembered that the patient's mental condition may preclude his giving any history of his case. Again, the infection may have occurred so long prior to the hemiplegia that he may have forgotten that he was ever the subject of syphilis. In other cases infection of the wife by the husband may have occurred, and the wife is rarely if ever informed that she has had the disease. This fact should always be remembered in attempting to trace infection in women.

5. Caries, necrosis, or nodes found upon the skull, or upon the long bones, especially with the concurrence of iritis, retinitis, or convulsions, are important signs of the nature of the affection. If these are discovered to have preceded or concurred with the hemiplegia, the syphilitic origin of the latter is rendered little short of certain.

6. Results of anti-syphilitic treatment. If improvement follows the administration of this class of medicines the presumption is fair that the disease was syphilitic—even in the absence of a history of the former infection.

Finally, if these diagnostic points be analyzed singly no positive diagnosis can be made, for the reason that this affection is not made manifest by any invariable symptoms or order of succession of such symptoms. The diagnosis rests upon the grouping of several or all of the signs before mentioned. Where the majority of them are found, a positive diagnosis can be made when no history of former infection is given.

The differential diagnosis between syphilitic and non-syphilitic tumors of the brain will be found under the head of Diagnosis of Epilepsy, on p. 664.

Syphilitic Insanity.—Acute and chronic mania, dementia, and general paralysis are occasionally observed as results of cerebral syphilis. There are no distinct symptoms by which either of these diseases can with certainty be diagnosticated. In fact, the whole subject is surrounded with much uncertainty. The history of a former syphilitic infection, or the manifestation of constitutional signs—such as cicatrices in the throat, nodes, enlarged glands, cutaneous eruptions, optic neuritis, etc.—will materially aid in arriving at a correct diagnosis. In these cases patients can give little or no history of their cases. It is therefore necessary that the physician should in every such case carefully examine the whole body for signs of former or present syphilitic infection. Fournier, a distinguished specialist and careful observer, has written upon this subject, and his views are presented as summarized by M. Ball ("Cornil on Syphilis," p. 323).

"According to Fournier, insanity attending syphilis presents itself either as a syphilitic dementia, as mania, or as general pseudo-paralysis.

"In syphilitic dementia the patient's temperament undergoes a radical change. His intelligence is clouded and his conduct strange. He becomes moody and taciturn. Labor is fatiguing and intolerable. His memory fails, though judgment often remains. Loss of memory may either be sudden or complete, or gradual and imperfect. The patient becomes careless as to his personal appearance, and very irritable. This condition may be designated as a precocious senility of the mind, differing from senile dementia, however, in being curable."

"Syphilitic mania may be suddenly developed or present prodromal symptoms. The latter, when present, consist in a peculiar excitement, feverish activity, and in unusual loquacity. These prodromata terminate in delirium, which may manifest itself in several forms. Sometimes it is active and attended by complete insomnia. The patient becomes destructive, and suicidal tendencies show themselves. The delirium assumes the form of hypochondriasis or syphiliphobia. The patient believes himself persecuted. The delirium is impulsive."

Syphilitic General Paralysis.—It is necessary in this disease to be able to diagnosticate it from non-syphilitic general paralysis of the insane. A summary of the points in contrast in the two diseases is given from a table compiled from a lecture by Dr. E. C. Seguin on in-

sanity, in 1878, to be found in "Cornil on Syphilis," p. 322. It is:

General Paralysis of the Insane.	*Syphilitic General Paralysis.*
Prodromal stage.	Absent.
Exalted notions, numerous and varied, and relatively exalted according to position in life.	Rare or absent.
Speech is tremulous and jerky.	Speech is thick.
Tremor of hands and lips.	Absent as a rule.
Preservation of strength.	Paresis or actual paralysis.
Pupils are apt to be contracted.	Apt to be open or wide.
No involvememt of cranial nerves.	Palsy of the third or other cranial nerves.
No headache.	Headache nocturnal.
Transient aphasic attacks.	More serious aphasic attacks.
Spontaneous remissions.	Progressive, except under treatment.
Abnormal cravings or appetites.	None.
Satyriasis.	Diminished virility.
Elevation of temperature.	Usually none.
Irritation and inco-ordination, usually without true paralysis.	Actual paralysis.

Syphilitic Aphasia.—This is a frequent result of cerebral syphilis. It is usually observed in the tertiary period, but is occasionally encountered in the secondary. It may manifest itself by hesitation in speech on the part of the patient, by an inability to call to mind certain words in speaking or writing, or by the inopportune use of words in attempting to make himself understood, or he may be able to use but two or three words of the language, etc. The aphasia may be constant or intermittent. There is nothing in this disease which of itself determines its origin. The history, and concurrent signs of syphilis must guide us in making a diagnosis.

Brain Syphilis Counterfeiting Sunstroke.—The writer has seen several cases of syphilis of the brain which were mistaken for sunstroke. The syphilitic causation, not having been detected in the earlier course of the disease, resulted in permanent disablement of two of the individuals. In such cases the individual, while engaged in the discharge of business engagements, is suddenly attacked with intense headache, vertigo, faintness, or loss of consciousness. Upon the return of consciousness, these symptoms are followed by marked impairment of strength, weariness upon making any physical or mental effort, succeeded by total incapacity for any kind of business. Sleepiness is a prominent manifestation. The appetite may be as usual, the food being ingested in quantities customary to the patient, but mental and physical prostration continue to oppress him. The patient having been exposed to the sun, or overpowered in a hot season, is considered to have had an attack of sunstroke. He may have forgotten that he had ever had syphilis, or, not appreciating it as causative of the present illness, he fails to call attention to former syphilitic infection. If paralysis does not follow, and no signs of syphilis be discovered on the body of the patient, the specific element of the disease is frequently overlooked, and, as a consequence, the patient often drags out a miserable existence from physical and mental infirmities. There are no symptoms pointing directly to syphilis as the cause of this disease. The diagnosis rests upon the history of former attacks of syphilis, and the concomitant signs of syphilis on the body of the patient. Unless the disease be promptly recognized and energetically treated permanent disablement usually results.

Syphilis of Cranial Nerves.—Syphilis, in consequence of lesions of the brain, or of its membranes, or of the skull, often produces impairment of function, or actual paralysis of cranial nerves. These affections are secondary in their nature, as these nerves are not affected except by pressure of neoplasms in the bone through which they find exit, or of neoplasms in the brain or membranes. These obstructions may produce neuritis, and finally atrophy of the nerve. The effect in these cases is similar to that of pressure from non-specific tumors of the brain. Syphilis may by congestive, hyperplastic, or gummatous developments in the connective-tissue or sheaths of these nerves themselves, while within the cranium, cause impairment or loss of function of cranial nerves.

The nerves most often involved are:

The Motor Oculi.—In this affection the first symptom is usually ptosis, with subsequent paralysis of the recti muscles, with external strabismus and mydriasis.

Of the motor cerebral nerves the seventh is the one next most frequently affected. No detailed description of this affection is necessary, as it is frequently met with in practice and is familiar to the general practitioner.

The sixth cranial nerve is oftentimes affected in brain syphilis, and may be the only one implicated. The prominent signs of paralysis of this nerve are internal strabismus, with diplopia.

The fifth nerve is frequently paralyzed in consequence of cerebral syphilis. If the whole of the nerve is involved the muscles of mastication become paralyzed. There are no diagnostic points by which this form of paralysis can be detected in its early stage, except concurrence of nocturnal pain. In this, as in paralysis of all other cranial nerves, the history of syphilitic infection, or the evidences of the disease on the body of the patient will aid in forming a correct diagnosis.

The optic nerve is more frequently attacked by syphilis than any of the nerves of special sense. Optic neuritis caused by syphilitic tumors differs in no way from that produced by non-syphilitic affections of the brain. The special features of syphilitic ocular diseases will be described by the writers of the various articles relating to diseases of the eye.

Prognosis.—The prognosis of cerebral syphilis varies with the location and extent of the lesion, and the length of time which the affection is permitted to exist without treatment. It must be admitted that the prognosis in this class of diseases is vastly more favorable than in non-syphilitic diseases with similar symptoms. These affections are among the most serious of the lesions which the syphilitic poison produces in the body. The functions of the brain are often hopelessly impaired by the anatomical changes caused by syphilitic infection, and death as the immediate result of these morbid developments is by no means rare. Syphilitic diseases of the brain are serious for the additional reason that, even where improvement is apparent, relapses frequently occur. When these affections have been recognized in their early stages, and prompt and energetic treatment applied, a fatal termination is comparatively infrequent. The power of remedies over these diseases is truly remarkable—far excelling anything observed in the treatment of non-syphilitic affections. However hopeful the case may appear the prognosis is to be considered better, so far as the immediate attack is concerned, under which the patient is suffering, than it is in regard to his future. The power of anti-syphilitic remedies to remove the immediate results of syphilis is greater than to eradicate the dyscrasia, and hence, when syphilitic neoplasms have been developed within the cranium the physician can never assert positively that they will not recur. On the contrary, so frequently are these recurrences observed that the physician has a continual dread of them, even in the face of judicious treatment, and he always fears that each return will be attended with greater danger than the preceding one. The hope of continued improvement of the patient is to be founded upon the recognition of the disease at a time prior to degenerative changes in the brain-substance, and upon prompt and long-continued treatment. If the treatment does not wholly prevent returns of neoplasms, it will cause prompt absorption of them. In such cases the hope of eventual recovery, or improvement to a fair state of health, is a rational one. If, however, the syphilitic nature of the affection be not promptly detected, most valuable time will be lost and the patient will be likely to fall into hopeless invalidism. Affections of the cranium, meninges, and outer surface of the brain, are far less grave than those situated in the deeper parts or at the base of the brain. Mental disorders, epilepsy, and hemiplegia when due to growths located on the periphery are favorable as to prognosis, for improvement or recovery in these affections is a matter of daily experience. Paralysis of cranial nerves, when caused by similar lesions with the above-mentioned diseases, admit of favorable prognosis. When hemiplegia is due to softening of the brain consequent upon tumors, arterial contractions, or occlusions, the

prognosis is unfavorable. Judicious treatment, long-continued, may arrest the progress of degenerative changes, but cannot restore disorganization of tissue.

Treatment.—In the treatment of syphilitic diseases of the brain, the physician should ever bear in mind the extreme delicacy of the structures involved, or threatened by diseased processes. If the periosteum is congested, the tendency to formation of nodes must be repressed. If gummata appear, they will cause serious mental or motor disturbances, with subsequent degenerative changes in the brain-substance if not promptly removed. If arteritis occurs it must be promptly arrested, or narrowing or occlusion of the affected vessels will ensue, and be followed by destruction of brain-tissue which no skill of the physician can restore. In order to combat syphilitic diseases of the brain they must be recognized early and attacked with vigorous anti-syphilitic remedies. The armamentarium of the medical man holds but few remedies powerful for the emergency which is upon him, and these must be used in large and oft-repeated doses. Mercury and iodide of potassium are mainly to be relied upon in this class of affections. It has come to be a fundamental principle among the general practitioners of medicine in this country that mercury is indicated in the treatment of secondary, and iodide of potassium in the tertiary lesions of syphilis. Unfortunately it is frequently impossible to make these refinements in diagnosis, *i.e.*, to say whether the particular lesion is a secondary or tertiary development. As a rule these affections are found in the tertiary period, but the exceptions to this rule are frequent. The most important point to be decided is, which of the two remedies—mercury or iodide of potassium—will most certainly and speedily arrest these growths and produce a retrograde process. If only one of them is to be administered, I am convinced, after repeated trials, that mercury is the most certain to produce the desired results. But in the face of serious lesions, where destruction of brain-substance is imminent, both mercury and iodide of potassium should be prescribed. Whenever intense cephalalgia, vertigo, mental disturbances, epilepsy, threatened or actual paralysis are met with in a syphilitic patient, both remedies should be persistently and unsparingly administered. Of the numerous preparations and modes of administering mercury, inunction with mercurial ointment is the best. It presents the advantage of introducing into the system the largest amount of the medicine possible, with the least detriment to digestion, and it can be used when the patient cannot or will not take mercury internally. The amount necessary to be used at one time varies with the urgency of the case. In severe cases inunction of one drachm daily should be directed. After marked improvement is observed in the patient's condition the amount may be reduced to half a drachm every second or third day. Mercurial stomatitis should be guarded against by giving fifteen grains (one gramme) of chlorate of potash three times daily. If stomatitis is seriously threatened, the mercurial should be discontinued for several days. As to the length of time during which large doses of mercury may be given in these cases, Yvaren laid down the golden rule when he said, "The treatment must be as obstinate as the disease." As a general rule, it is well to prescribe fifteen grains (one gramme) of mercurial ointment, to be rubbed in every third day for several weeks after all serious symptoms have disappeared.

After discontinuance of the inunctions the patient should from time to time take small doses of mercury internally for the next two years. Plummer's pills are well tolerated, and have a happy effect in subduing the disease. One or two of these pills should be given each night and morning for a period of several weeks. Or a mixed treatment of mercury and iodide of potassium, like the following formula, may be given:

℞. Hydrargyri bichloridi............ grs. viij.
Potassii iodidi... .... ʒ v.
Aquæ.......................... ℥ viij.

M. Sig.—Shake bottle and take a teaspoonful in a wine-glass of water after each meal-time.

In cases of marked anæmia the following combination of mercury and iron may be used with benefit:

℞. Pilulæ hydrargyri.................. ℈ij.
Ferri sulphatis exsiccati.............. ℈j.
Extracti opii,........................ gr. v.

Mix and divide into twenty pills. Sig.—Dose, one pill three times daily.

In the treatment of syphilitic nervous affections the iodide of potassium is a valuable remedy. The writer regards it as an adjuvant to the mercurial treatment. In serious cases inunction of mercury with the internal administration of iodide of potassium should invariably be prescribed; the dose of the iodide varying from five to sixty grains, three times daily, according to the urgency of the symptoms. The effect of iodide of potassium alone, in the treatment of some of these cases, is often truly phenomenal. Unfortunately for this remedy, it has greater power to subdue present symptoms than to permanently control them. Upon the discontinuance of the iodide the symptoms often recur with a virulence equal to that which characterized them prior to its use. In such cases the patient must continue to use this remedy almost indefinitely, or resort to mercury for more abiding results. In yet other cases the iodide produces marked diminution of the symptoms up to a certain point, but beyond this no improvement takes place, no matter how large the dose, nor how long the remedy is used. In these cases rapid and marked improvement will follow if mercury is called to the aid of the iodide. Cachexia, not connected with lardaceous changes, is no contra-indication to the use of either the iodide or the mercury. During the continuance of either or both of these remedies marked improvement will be observed in the mental and physical condition of the patient. His appetite will increase and be followed by improvement in flesh and strength. The writer has frequently observed remarkable effects from the following prescription, when the iodide alone was of questionable benefit:

℞. Ferri et potassii tartratis............ ʒ v.
Potassii iodidi..................... ʒ x.
Aquæ.......................... ℥ viij.

M. Sig.—Shake bottle and take a teaspoonful in a wine-glass of water after each meal.

Individuals are occasionally met with who cannot take iodide of potassium even in minute doses. In all such mercury must be prescribed. During the administration of the iodide, symptoms of iodism, partial or complete, often appear. Not infrequently these symptoms disappear entirely when the remedy is continued and the dose increased; a continuance of the treatment with the iodide seeming to establish a tolerance of it in many of these cases. The physician should, therefore, be well satisfied of the inability of his patient to take this medicine before he abandons its use.

In the treatment of syphilitic diseases of the brain associated with lardaceous changes, neither iodide of potassium nor mercury should be given until preceded by other remedies. Here preparations of iron, cod-liver oil, and moderate doses of stimulants should be prescribed, and a full and nutritious diet, with careful attention to the hygienic surroundings of the patient, should be directed. After this preliminary course of treatment large doses of iron, combined with minute doses of mercury, should be cautiously given, and followed by iodide of potassium if indicated.

Finally, and almost as important as any part of the treatment of syphilitic diseases of the brain, the hygiene of each patient must engage the constant attention of the physician. Rest of mind and body must be insisted upon. The individual should abandon business, and devote himself to the duty of attempting to regain his health. Mental application to study or business pursuits will be followed by calamitous results. Undue physical exertion, sexual indulgences, smoking, free use of alcohol, exciting scenes, etc., are all to be interdicted. The alvine, renal, and hepatic functions, must be maintained as in health. The diet should be abundant in quantity,

nutritious, and easy of digestion, and taken regularly. The sleep of the patient should be restful, and of proper lengths of time. If necessary to secure it, hydrate of chloral and bromide of potassium should be given as indicated. Paralysis, continuing after disappearance of the other symptoms, must be treated by daily frictions, massage, electricity, etc. This treatment may have to be continued for weeks or months before marked improvement is observed. The persistent and methodical application of these remedial measures will often prevent atrophy of the affected muscles. *Eugene Foster.*

BRAIN, TUMORS OF THE. The symptoms caused by tumors of the brain are due, first, to irritation or destruction of the portions of the nerve-tissue in which they are embedded, or near to which they lie; second, to pressure exercised upon the entire contents of the cranium —nerve-tissue, blood-vessels, and lymphatics. The first class of symptoms are common to tumor, and to all other circumscribed lesions of the same locality, thus especially patches of chronic softening. The second class are common to all conditions in which the intracranial space is encroached upon; such are extra- as well as intra-cerebral tumors, morbid products within the brain, which differ considerably from neoplasms proper, and, finally, abscesses and aneurisms. Thus, the investigation of the case of any patient exhibiting cerebral symptoms demands that we decide: First, whether these are caused by a new growth of any kind, which is encroaching upon the cranial cavity; second, this being admitted, what is the nature of the growth; third, what is its precise locality.

The prognosis must then be framed according to the fact, the nature, and the seat of the growth; and, finally, the (very limited) indications for treatment must be considered.

Symptoms Indicating the Existence of an Intracranial Growth.—These are of two kinds: those belonging to the perversion or abolition of cerebral function, and those indicating a rise of intracranial pressure. The first are the focal, the second the diffused symptoms (Griesinger). It is this second class of symptoms which are of the most importance in distinguishing between tumor and other cerebral lesions, and they may therefore be considered first.

Diffused Symptoms.—These are headache, vertigo, vomiting, general epileptiform convulsions, apoplectiform attacks, psychic disturbances, and choked disk.

Headache is one of the earliest and most constant symptoms of intracranial tumor. It is also often one of the most severe, and, by its persistence and intensity, may be usually distinguished from cephalalgia of other causation. It may precede all other symptoms of the disease for some time, and it is then that some absolutely pathognomonic characteristic would be most desirable, but is hard to find. In a certain number of cases the seat of the headache corresponds to the seat of the tumor; this is oftenest the case with tumors, intra- or extra-cerebral, which occupy the posterior cranial fossa. Even here, however, the pain is sometimes frontal. Localized percussion will sometimes greatly intensify the pain at a particular point; and this may be found to correspond to the seat of the tumor. The headache is often periodic, and then is easily mistaken for an apyretic malarial attack. This is especially the case when a frontal headache seems to imitate brow-ague. On the other hand, occipital headache may simulate the cervico-occipital neuralgia of gouty persons. The diagnosis may be facilitated in either case by careful exploration along the track of the nerve. Nocturnal headache resembles the syphilitic cephalalgia; and the question is rendered all the more difficult from the fact that brain tumors are frequently of a syphilitic nature.

Although so prominent a symptom when it exists, headache is by no means always present. It was absent in one hundred and forty-eight out of two hundred and seventy-four cases analyzed by Ball and Krishaber.[1] By combining the tables of Ladame and of Bernhardt (the first summing up all cases published earlier than 1868, the second those between that date and 1880), we can construct the following table, showing the proportion of cases of headache with cerebral tumors of different localities.

Table I.

Seat.	No. of cases.	No. with headache.	Per cent.
Cerebral peduncle	10	4	40
Basal ganglia	41	19	48
Cortex	74	37	50
Medulla	28	16	60
Cerebral lobes	196	129	66
Pons	56	37	67
Cerebellum	186	150	81
Corpora quadrigemina	13	9	69

This table helps to confirm the inferences that might be drawn from the physiology of pain. It is rarely to be attributed to irritation of sensory centres; but rather to the stretching of the dura mater, with its rich supply of sensory nerve-filaments from the trigeminus. As some degree of stretching always takes place, no matter what the seat of the tumor, headache is always imminent, but it may not manifest itself if the tumor grows very slowly, and makes way for itself by gradual compression of the brain-substance, and displacement of its fluids. On the other hand, the pain is most certain to occur, and also to be most violent, when the tumor grows in the cerebellum under the tense fold of the tentorium; it is least likely to occur when room is left for the expansion of the growth at the interpeduncular space. In the pons and medulla, direct irritation of the trigeminus may add a special liability to pain. The great liability to headache with tumors of the corpora quadrigemina may perhaps be due to their intimate connections with the cerebellum. In the cortex, only half the cases are attended by headache; this probably being due to the tendency of the tumor to grow downward, and thus to relieve the tension of the dura. The periodicity in the pain is undoubtedly associated with fluctuations of the circulation, always liable to be diurnally periodic. An initial headache often disappears when paralysis sets in; probably because, by that time, a zone of softening has usually developed around the tumor. The intensity of the pressure is at first either partially or entirely relieved; headache may set in, if the tumor suddenly assume a more rapid rate of growth; it necessarily subsides at the appearance of the terminal symptoms of drowsiness and comatose apathy, the pain being blunted, like other signs of irritation, in the general depression of the sensibility.

Vertigo is a prominent symptom of any organic brain disease, and although frequently present with tumor, is far from characteristic of it. It is probably always associated with direct or indirect irritation of those portions of the brain which are concerned in equilibration; and it agrees well with this presumption that vertigo so much more frequently occurs with tumors of the cerebellum than with those of other parts of the brain. Other "space-encroaching" lesions, *e.g.*, abscesses, so situated as to affect the middle or internal ear, may cause vertigo by the same mechanism as that which is brought into play in ear disease proper, namely, by excitation of the auditory nerve. As the central fibres of this nerve have been traced to the cerebellum, it seems probable that the sensation of vertigo, whether cerebral or aural in origin, is always finally produced by the same mechanism. The third diffused symptom, *vomiting*, follows the same law of predominance as headache and vertigo, namely, it is much more frequent and severe in tumors of the cerebellum than in those involving some other portion of the brain, with the exception of the corpora quadrigemina, where the liability is at the maximum.

From the following table it appears that vomiting is a much less frequent symptom than headache, but follows exactly the same order of predominance, except in respect to the centrum ovale. This is because the vomiting is partly due to the same cause as the headache, namely, the extreme tension of the tentorium. Extreme tension does not, however, always cause vomiting.

TABLE II.

Seat of tumor.	Headache.		Vomiting.		Convulsion.		Choked disk (Bernhardt alone).						
							Amaurosis.		Vision intact.			Total.	
	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.		Cases.	Per cent.
Cerebral peduncle..	4	40.0	..	....	2	20.0	....		....			....	...
Cerebral lobes	129	66.0	36	18.5	49	26.0	15 in 124	12.0	12 in 124	9.0	=	27 in 124	21.0
Basal ganglia	19	46.0	8	19.5	7	19.0	....		2 in 26	5.0	=	2 in 26	7.0
Cortex	37	50.0	18	23.0	20	25.0	5 in 57	8.0	5 in 57	9.0	=	10 in 57	17.0
Pons..............	37	67.0	15	27.0	2	5.0	4 in 30	13.0	2 in 30	6.0	=	6 in 30	20.0
Medulla...........	16	60.0	12	40.0	2	6.0	....		2 in 21	9.0	=	....	9.0
Cerebellum........	150	83.0	75	45 0	18	12.0	18 in 90	20.0	13 in 90	14.0	=	31 in 90	34.0
Corp. quad........	9	69.0	8	61.0	1	....	5 in 11	45.0	1 in 11	10.0	=	6 in 11	54.0
Total...........	423 in 568 cases = 74 per cent.		172 in 568 cases = 30 per cent.		91 in 568 cases = 16 per cent.		82 in 362 cases = 22 per cent.						

Case, by King (*Brain*, October, 1882): Two tumors, one on right side of pons extending to left middle peduncle of the cerebellum, the second embedded in the left side of the floor of the fourth ventricle, convolutions flattened, much serum in ventricles, showing extreme intracranial pressure; but optic neuritis developed only after attacks of coma. Headache, but no vomiting.

The immediate cause of vomiting is supposed to be always the excitation of a vomiting centre in the medulla; and this can be brought about by pressure transmitted from any part of the brain. This pressure is, however, more direct when exercised from some point in the posterior cranial fossa; hence a second reason for the intensity of the symptom in cases of tumor of this locality.

Epileptiform convulsions constitute a fourth diffused symptom, which is very characteristic of tumors of the brain. Their causal relations to increased intracranial pressure has been strikingly shown by Leyden's experiments. In these, pressure was directly applied to the brain of animals previously trepanned for the purpose. Convulsions occurred as soon as the pressure had risen to 130 mm. of mercury. Pressure, however, is only one of the mechanisms by which convulsions may be excited. Kussmaul's experiments, made many years ago, showed that sudden anæmia of the brain, such as might be induced by copious hæmorrhage, was invariably followed by convulsions. The predominance of convulsions in cases of brain tumor, according to the locality occupied by the latter, does not follow the law which is applicable to symptoms traceable to increased pressure, for convulsions occur oftenest in cases of tumor of the cortex and cerebral lobes, presumably of the portions of the centrum ovale which lie immediately beneath the cortex. General convulsions, therefore, like local spasms, are rendered imminent by direct excitation of the motor tracts. Curiously enough, convulsions are almost excluded from the symptomatology of the pons, though this region, which is traversed in every direction by motor tracts, probably contains the convulsing centre. But apparently the properties of the centre become abolished before they can be effectually irritated. This absence of convulsions, when certain positive signs are present at the same time, is of real value in localizing a tumor in the pons.

As the convulsion is not proportioned to the locality of greatest tension, so it stands in no relation to the time at which tension is greatest. It occurs as an initial symptom, or during the active period of the disease; but it usually disappears, with other irritative symptoms, in some other manner toward the close, when intracranial pressure is at its maximum. Sudden variations in such pressure, caused by fluctuations of the circulation, seem to be the essential proximate cause of the convulsions of brain tumors. The form of the convulsion does not differ from that observed in idiopathic epilepsy, and the diagnosis between tumor and epilepsy is often difficult. It can only be made by means of the concomitant symptoms.

Apoplectiform attacks occur with brain tumors, and may, though rarely, be the first symptom and followed by paralysis or paresis. It is extremely difficult, then, to distinguish the case from one of ordinary cerebral hæmorrhage. Hæmorrhage into or around the tumor is a frequent cause of apoplexy, and thus may first reveal the existence of a tumor hitherto latent; or it may occur incidentally among phenomena already well defined and recognized. Finally, the apoplectic attack may usher in the terminal period; the patient never completely recovering, but passing into a soporose condition and finally into coma. The apoplectic ictus is not invariably associated with hæmorrhage; it may be due to sudden alterations of intracranial pressure, by which the functions of brain-tissue are temporarily suspended, as after concussion.

Psychic Changes.—The earliest is usually an extreme irritability, which contrasts with the lachrymose emotionality characteristic of softening of the brain. Occasionally this culminates in attacks of maniacal excitement; oftener, however, the patient suffers from melancholic depression, and gradually becomes more and more apathetic and taciturn. This taciturnity, which is a diffused symptom, must be distinguished from true aphasia. As in all mental disturbances, the memory fails. Dementia may precede death for some time, especially if epileptic convulsions have been severe.

Case VII., by Mills:[2] Attacks of mania at intervals. Tumor occupies occipital and postero-parietal gyri.

Case, by Hunt:[3] Speech mumbling, thick, no wrong words, mental confusion, drowsiness, loss of memory. Tumor occupies angular and supramarginal gyri.

When tumor complicates a diffused meningo-encephalitis, the mental symptoms are attributable rather to that.

Case, by Magnan (*Brain*, 1879): Angiolithic sarcoma (psammoma), reducing ascending parietal gyrus to one-third its volume, associated with diffuse meningo-encephalitis; epileptiform convulsions for eight years; intellectual faculties impaired; loss of memory and moral sense; mania, dementia.

The following case is remarkable for the short duration of the symptoms:

Case, by Bristowe (*Brain*, 1884): First symptoms fourteen weeks before death. Intelligence early impaired, after headache and right hemiparesis. With progress of paresis patient became stupid, drowsy, finally comatose. Tumor in anterior part of corpus callosum.

It is extremely noticeable from Table III., that the liability to perversion of intelligence is not at its maximum when the tumor is seated at the cortex, nor when a cortical tumor is in the frontal lobes. Cortical tumors stand third from the bottom of the scale, in this respect; the highest place is occupied by tumors of the corpora quadrigemina, seventy-seven per cent. A relative infrequence of mental disturbances is observed in tumors of the medulla and pons. On the other hand, the high percentage of such disturbances in tumors of the centrum ovale may probably be, at least in part, attributed to their influence upon the cortex. To such influence must, in last analysis, all psychic perversions be ascribed; and the high proportion of cases in which these are present with tumor in any locality of the brain, is explained by the extreme sensitiveness of the cortical substance to disturbance of the intracranial pressure from whatever point diffused. Psychic symptoms, of one kind or another, are seen to be extremely frequent in tumors of the brain, being present in about half the cases. Their presence, therefore, materially aids in establishing the diagnosis.

Choked Disk.—This symptom, when present, is more nearly pathognomonic, than any other, of cerebral tumor. The phenomenon of the choked disk has been regarded as

TABLE III.

Seat of tumor.	Intelligence Disturbed.										Intelligence Normal.	
	Mental depression, apathy, loss of memory, imbecility.		Hallucinations.		Delirium or mania.		Drowsiness or stupor.		Total.			
	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.
Medulla, 29 cases	6	20.0	2	7.0	2	7.0	1	3.5	11	38.0	18	62.0
Cerebellum, 162 cases	48	29.0	1	..	6	3.0	9	5.0	64	39.0	98	60.0
Cortex, 57 cases	..	....	..	.	..	...	..	...	28	49.0	..	...
Pons, 56 cases	27	48.0	1	..	..	...	1	...	29	51.5	27	48.5
Basal ganglia, 40 cases	18	45.0	1	..	2	...	.	...	21	52.0	19	47.0
Lobes, 192 cases	90	46.5	9	4.0	11	5.5	5	2.5	115	60.0	77	40.0
Occipital	1	....	.	..	..	...	..	...	..	..	1	...
Frontal	6	10.0	.	..	..	...	..	...	6	10.0	11	19.0
Parietal	9	15.5	1	..	2	...	7	12.0	19	33.0	17	29.5
Temporal	2	3.0		..	.	...	..	...	..	...	..	...
Corp. quad., 13 cases	4	30.0	..	...	2	15.0	4	30.0	10	77.0	3	23.0

the expression of two different morbid processes—the one an inflammation of the optic nerve, the other a mechanical obstruction to its circulation. In either case, to the ophthalmoscope the papilla appears engorged, tumefied, nebulous, irregular, and with ill-defined edges; a species of cloud covers both the centre and the circumference, rendering the whole surface opaque. The arteries are diminished in calibre; the veins appear interrupted at various points. In one form of choked disk, probably the inflammatory, the capillaries seem increased in size, in the other effaced.

According to the celebrated doctrine of von Graefe, these appearances are always due to an obstruction offered to the venous circulation of the optic nerve, from mediate or immediate pressure exercised upon the sinus cavernosus. Hence a serous transudation from the veins, rendering the papilla swollen and œdematous. It has been shown, however, that the free inosculation of the ophthalmic vein with the angular branch of the facial, suffices to avert complete venous obstruction, even when the circulation in the cavernous sinus has been retarded. Further, a free communication has been demonstrated between the intervaginal lymphatic space of the optic nerve and the subarachnoid space of the brain. It has been shown that a rise of intracranial pressure suffices to force cerebro-spinal fluid into the intervaginal space of the nerve, thus causing compression of its central vessels, local obstruction, and swelling from transudation, apart from venous obstructions.

Choked disk sometimes appears in cases in which the tumor is so small that much increase of intracranial pressure seems doubtful. It is then more probably due to inflammation of the optic nerve, first propagated from irritated brain-tissue to the central terminations of the nerve—neuritis from diffused cerebritis (Mackenzie), or excited by direct pressure upon the optic tract. The latter may be effected by tumors of the corpora quadrigemina, of the cerebral peduncles, or of the interpeduncular space. The table given on p. 669 shows that the percentage of cases of choked disk, in cases of intracranial tumor, is greater in this locality than in any other. But as shown by Table X. it is only present in twenty-two per cent. of all cases hitherto observed, thus is less frequent than any of the diffused symptoms except convulsion.

Choked disk is found far more frequently (54 per cent.) in cases in which the tumor involves the corpora quadrigemina, than in those in which it involves any other part of the brain. The smallest percentage is in the class of cases in which the basal ganglia are the seat of the tumor. When there is direct pressure on the optic tract, the papilla sometimes atrophies without passing through any stage of choked disk. Until atrophy sets in, vision is not necessarily impaired. Thus, out of a total of 82 cases of choked disk, vision remained intact in 37, or 45 per cent. In a great many cases no ophthalmoscopic examination is made, unless vision is impaired, and this explains why such examination is lacking to the history in 232 out of 485 observations analyzed by Bernhardt (47.8 per cent.). In many of these negative cases it is very possible that choked disk really existed, so that the real proportion of this lesion in brain-tumor cannot be considered as known.

In a certain number of cases cerebral tumor manifests itself exclusively by one or more of the foregoing "diffuse" symptoms. Among Bernhardt's cases of tumors of the cortex, centrum ovale, cerebellum, and basal ganglia, this limitation may be found seventy-one times out of a total of 297 cases, or 23.8 per cent.

The existence of mental symptoms in a large proportion of these cases (49 per cent. of them) is the circumstance that might, perhaps, most surely guide in the diagnosis, otherwise so difficult.

TABLE IV.—CASES OF DIFFUSED SYMPTOMS ALONE.

Seat.	Headache.	Headache and vomiting.	Headache and convulsions.	Headache and choked disk.	Headache, convulsions, and vomiting.	Headache, convulsions, and choked disk.	Headache, convulsions, vomiting, and choked disk.	Headache, vomiting, and choked disk.	Vomiting.	Convulsions.	Convulsion and choked disk.	Psychic alteration.	Total.
Cortex, 57 cases	4	3	1	.	..	1		..	..	1	1	In 7 of these.	11 = 19 per cent.
Lobes, 124 cases	5	3	8	2	4	5		3	2	4	1	In 22 of these.	37 = 29 per cent.
Basal ganglia, 26 cases	2	1	..	..	..	..		.	..	2	..	1 alone, 1 besides.	6 = 23 per cent.
Cerebellum, 90 cases	2	6	1	..	3	..	..	4	..	1	..	In 4 of these.	17 = 18.5 per cent.
Total	13	13	10	2	7	6		7	2	8	2	35	71 = 23.8 per cent.

The proximate consequences of increased intracranial pressure, and which are the immediate cause of the diffused symptoms, have been differently interpreted. It was long maintained that the brain substance was nearly as incompressible as water. Room, therefore, could only be made within the cranium for a neoplasm, by proportionate expulsion of blood and lymph, and by atrophy of the brain-tissues in the immediate vicinity of the tumor. Adamkiewicz's experiments have shown, however, that the nerve-tissue surrounding the tumor is compressed, *i.e.*, its solid molecules are approximated, and the fluid, normally interposed between them, is, to a greater or less extent, expelled. For, when a piece of laminaria was inserted under the skull of an animal previously trepanned for the purpose, and was allowed to swell, thus rapidly encroaching upon the intracranial space, microscopic examination of the tissue in which the foreign body was embedded revealed the fact that all the nerve-elements of this tissue were closely crowded together, thus apparently

multiplied in a given space. The zone adjacent to this was intensely vascularized from dilatation and new development of capillaries, and, in addition, it was hypertrophied from proliferation of connective-tissue.

In the experiment, the swelling of the laminaria was much more rapid than is the growth of any tumor, and the condensation and nutritive irritation of tissue were, therefore, exaggerated. To a greater or less extent, however, both these lesions must always be produced by the presence of a foreign body within the cavity of the cranium. Only when the tumor grows very slowly are they absent, or reduced to such a minimum as to occasion no symptoms, either diffused or focal.

The occurrence, in twenty-three per cent. of the cases, of diffused without focal symptoms, indicates that the centres of origin of nerve-tracts have remained unaffected, though the vomiting and convulsive centres and the nervous filaments of the dura mater have been irritated; that lymph has been forced into the sheath of the optic nerve, or that a descending neuritis has been excited by propagation from the zone of cerebritis surrounding the tumor; * and that the delicate psychic mechanisms of the cerebral cortex have been irreparably jarred and are out of working order.

This immunity of motor, sensory, or special-sense nerve-functions is usually due to the localization of the tumor in a "latent" portion of the brain, but it is also sometimes observed in cases in which the tumor occupies a (presumable) focus of nerve-origin. Thus, although there can be no doubt that the ultimate origin of the motor nerves contained in the pyramidal tracts is in the central gyri and paracentral lobule, tumors seated in these localities have sometimes been observed entirely unaccompanied by motor symptoms, either irritative or paralytic. Two such cases are contained among the eleven of the table. In one of these there were forty hydatid cysts in the brain, a form of neoplasm very frequently latent.[4] In the second case, however, there was a most extensive sarcoma occupying the lower half of the anterior central gyrus, posterior half of third frontal gyrus, and under half of insula.[5]

Two explanations are offered for these cases. First, that the elements of the neoplasm have insinuated themselves so gradually between those of the nerve-tissue, or have displaced them with so little injury that the functions of this tissue have not suffered. This explanation applies to cases in which, instead of the cells of a nucleus of origin, the fibres of a nerve-tract have been displaced, as in some extraordinary cases on record in which a tumor has occupied nearly the entire pons, yet has occasioned no motor symptoms. The second explanation applies only to cortical centres. According to Exner, the different mechanisms of the cortex, though specially concentrated at certain localities, exert their influence somewhat beyond these limits, though with constantly diminishing intensity and effectiveness. Hence it is occasionally possible, though the main centre be destroyed, that its action may be supplemented by that of others habitually subordinate.

In more than three-fourths of the cases of brain-tumor, in addition to the diffused symptoms hitherto described, the patient suffers from perversions or abolition of one or more cerebral functions other than psychic ones. These are known as the focal symptoms.

Focal Symptoms.—They consist of the perversion or abolition of mobility or sensibility in one or more cranial nerves or spinal nerve-tracts; or in similar alterations of one or more of the special senses. Among the latter, however, is to be excepted the impairment of vision directly traceable to choked disk or optic neuritis. An intense interest has recently attached to these symptoms, as a means of unravelling the physiological problems of the localization of brain functions. For this purpose, however, the study of tumors is much less valuable than that of other brain lesions, such as, for example, localized softening; for their limits are irregular, and their effects, through transmission of pressure, often diffuse themselves in structural or functional changes far beyond these visible limits. For clinical purposes, therefore, it is necessary to ascertain first, what symptoms are generated by lesions really limited to certain localities; second, to what extent the complication of these by others, diffused or symptomatic of different localities, may aid us in diagnosing the existence of tumor as distinguished from other focal disease.

Focal symptoms are always unilateral at the beginning —a most useful criterion in distinguishing tumor (as well as other localized lesions) from a diffused disease of the brain. The appearance of symptoms on the opposite side of the body from that on which they first began, indicates an extension of the growth across the median line. This, for obvious reasons, most frequently occurs at the narrowest regions of the encephalon, the pons and (though less frequently) the medulla. It is, however, also seen in tumors of the corpus callosum, but the second hemiparalysis is much slighter than the first.

Case (Bristowe, *Brain*, October, 1884): Illness twelve weeks. Left hemiplegia, gradually extending to right side; then general paralysis, principally on the left side, ten days before death. Progressive drowsinss or stupidity, aphasia. Sarcoma occupied anterior two-thirds of fornix and corpus callosum, extending into the centrum ovale in both hemispheres, but principally in the right.

In addition to these symptoms involving purely cerebral functions, the functions of respiration and circulation are sometimes modified from the direct or indirect morbid influence exercised upon the medullary centres.

Lesions of Motility.—These are by far the most numerous, the most varied in character and in combination, of all the focal symptoms of brain tumor. They belong to three different classes: First, irritative, including tremors, choreiform movements, and local spasms; * second, ataxic, implying inco-ordination among functionally combined movements; third, paralytic, consisting in the partial or complete abolition of motive power.

Irritative Lesions of Mobility.—A fine tremor or a clonic spasm, incessant or periodically repeated, is often seen, either in muscles which have already become paralyzed, or in those which become paralyzed at a later date.

Case (Berger, *Arch. der Heilkunde*, XIX. Jahr.): Woman, aged forty-eight. During a year, about every eight days, an attack of clonic spasms in the right arm, then paralysis of the same arm, followed by paresis of the buccal branches of the right facial: clonic spasms persist after paralysis sets in; death a week later. Tumor in left anterior central gyrus, compressing the posterior and second frontal gyri.

Case (Berkley, *Med. News*, 1882): Patient with spasm of the left angle of the mouth for two and a half years. Sudden death from cardiac disease. Calcareous nodule three-sixteenths of an inch in diameter on the right ascending frontal convolution, one and a half inch above the fissure of Sylvius; the locality corresponds to Ferrier's centre for the zygomatic muscles.

Tremors and localized spasms are valuable diagnostic symptoms; for, first, they are more frequent with tumors than with other localized brain lesions; second, they are more frequent in the cortex; and, third, they are especially frequent in the motor zones. All these circumstances are demonstrated by the following tables. The first is compiled from Exner's collection of one hundred and sixty-four cases, exclusively of cortical lesions.

Tumors of cortex (44 cases): Spasm, 3 = 6.5 per cent.; spasm and paralysis, 14 = 31 per cent.; paralysis, 14 = 31 per cent.; no motor symptoms, 13 = 29 per cent. Total spasm, 17 = 38 per cent.

Other lesions of cortex (100 cases): Spasm, 1 = 0.9 per cent.; spasm and paralysis, 13 = 11.5 per cent.; paralysis, 62 = 56 per cent.; no motor symptoms, 36 = 32 per cent. Total spasm, 14 = 12 per cent.

Thus, in more than one-third of all cases of brain tumor, localized spasms or contractures exist at some period of the disease. When present, they indicate a greater probability of localization in the cortex than in any other part of the brain; and after that, in the region of the corpus striatum and thalamus opticus. In the table, the highest

* Demonstrated by Adamkiewicz (see *ut supra*).

* The general epileptiform convulsions being a diffuse symptom.

percentage falls to tumors of the peduncle; but this fact is offset by the great rarity of tumors in this region.

TABLE V.—PROPORTION OF CASES OF SPASM WITH TUMORS.

Seat.	No. of cases.	Spasm.	Spasms and paralysis.	Paralysis.	Total spasm.	Percentage.	No motor symptoms (except ataxic).
Cortex—							
Central gyri	39	4	24	10	28	71	2
Parietal lobe (motor)...........	11	..	7	1	7	63	3
Total motor zone	50	4	31	11	35	70	5
Frontal gyri.. ..	14	2	1	4	3	21	7
Other latent parts	13	1	2	2	3	23	8
							Per cent.
Total cortex...	77	7	34	17	41	53	20 = 25.0
Centrum ovale....	124	12	22	45	34	27	45 = 36.0
Basal ganglia......	41	9	10	14	19	46	8 = 19.0
Peduncle..........	10	1	5	3	6	60	2 = 20.0
Corp. quad........	13	1	3	2	4	30	7 = 53.0
Pons..............	56	3	7	38	10	17	8 = 14.0
Cerebellum........	165	20	12	26	32	19	107 = 64.5
Medulla...........	30	8	2	15	10	33	5 = 16.0
Total	516	..	..	..	156	30	202 = 37.5

It is evident that spasmodic contractions of muscles may be caused by irritation, either of the nerve-elements of a motor-centre, or of the fibres of a motor-tract descending from it, but that the first condition is more favorable. Tumors of the pons and medulla are rarely accompanied by spasm; it seems that the liability to irritation increases higher up in the tract, and also when the latter is more incompletely invaded.

Paralyses of Motility.—These are especially characterized, as a rule, by their gradual development, a circumstance which is most useful in distinguishing brain tumors from hæmorrhage. It does not, however, serve to differentiate tumors from softening, for in the latter the paralysis is also gradually developed.

To a certain extent the paralyses of tumors share the peculiarities of those caused by other lesions of the same locality. As already stated, however, in the case of tumors, the paralyses are rarely purely typical throughout the whole course of the disease, because they constantly tend to encroach upon other regions than that in which they originated; and because their influence, by transmitted pressure and nutritive irritation, is apt at all times to diffuse itself considerably beyond the region which they visibly occupy. A paralysis which may seem at a given stage to be entirely atypical, may, however, exhibit in the history of its development peculiarities which point out the true nature of the disease. The paralysis has been preceded by a slowly progressing paresis, or by tremor or spasm in the affected muscles, or has existed in one set of muscles, or in one limb, or in one or more cranial nerves; or there has been a combination of paralyses of such nerves with others of the extremities, before the disease reached its complete evolution. Or, further, the very first appearance of paralysis may have been preceded by one or more diffused symptoms; or it may have been ushered in by an epileptiform convulsion or an apoplectic attack, remarkable for its brevity and incompleteness. Or a paralysis may declare itself at once, in a fully developed form, but isolated, as in one facial nerve, and after prolonged headache, attacks of vomiting, and change of mind or character of the patient. The typical characteristics of the paralyses, according to locality, are as follows:

Cortex.—The paralysis, at the outset at least, is "dissociated," monoplegic. One arm or one side of the face is affected, or the two together are affected on the same side. It is extremely rare that paralysis begins in the leg; but this extremity often becomes involved later, and then the patient suffers from a complete hemiplegia, difficult to distinguish at first from the common hemiplegia due to hæmorrhage into the internal capsule. It is very rare, however, that the paralyzed limbs become rigid. It is with tumors in this region that clonic spasms are most frequent, either before or during the paralysis. Symptoms of tumors of different regions of the cortex follow, approximately, the rules which have been laid down for other lesions, according as they occupy the "latent" or the motor zones. The latent regions are those parts of the brain in which, with rare exceptions, lesions produce no motor symptoms. The motor-zones are those whose lesions are always followed by spasm or paralysis, except in a very few cases, in which the absence of symptoms is explained by the extremely slow growth of the tumor, which allows nerve-tissue to accommodate itself to increased pressure. When an "absolute field" exists it will be found that, in all cases in which motor symptoms are absent, this field is entirely free from lesion. In the regions adjacent to these, lesions sometimes do and sometimes do not produce symptoms. This fact, as already stated, has been explained in two ways—by the theory of transmitted pressure, and by the theory of a "relative field," which contains motor mechanisms of less degree of intensity and concentration than those belonging to the "absolute field." The absolute motor zones are:

First, for the upper extremity, the anterior central convolutions, especially the lower two-thirds, the upper half of the posterior central convolution, the paracentral lobule, and, in the left hemisphere, the greatest part of the superior parietal lobe, and possibly a few points on the occipital.

Second, for the lower extremity, it is the upper third of both central convolutions and the paracentral lobule, and in the left hemisphere again the greater part of the superior parietal lobe. This "absolute field" is, according to Exner, surrounded by a relative field which occupies the posterior half of the superior frontal gyrus, almost the entire convex surface of the other two frontal gyri, both parietal lobes, and the upper part of the occipital lobe. This field belongs to both extremities.

Third, there is no absolute field for either facial muscles or tongue, the mechanisms for both seeming to be diffused over the greatest part of the hemispheres. But the seat of greatest concentration, for the facial nerve, exists at the lower half of the anterior central gyrus, and the lower third of the posterior central; while a relative field extends over the posterior half of both lower frontal gyri and the anterior part of the supramarginal gyrus. The principal centre for the hypoglossal nerve is the lower part of the anterior central gyrus and adjacent part of the middle and inferior frontal gyri.

Fourth, no definite cortical field has been outlined for either the motor oculi nerve or the trigeminus. In regard to the first, however, it seems certain that all the branches of both nerves are influenced by the centres of a single hemisphere.

The zone for common sensibility coincides with the motor zone as above defined.

Fifth, the zones latent in regard to motor or sensory symptoms include all the frontal lobes, the temporo-sphenoidal lobes, the parietal lobe of the right hemisphere, and the occipital lobes. Lesions of these lobes may remain absolutely latent, and did so in 13 of Exner's 44 cases of tumors, that is, in 29 per cent. But, even when unattended by paralysis or spasm, lesions of these latent zones are liable to be followed by such disorders of speech, of vision, or of hearing as lead to the localization, within their boundaries, of the centres for these important functions.* In Table V. it will be seen that there were 9 cases of paralysis, with or without spasm, occasioned by tumors in the non-motor regions; the percentage of paralysis to whole number of such tumors being 37 per cent. Out of the whole number of cases of paralysis from 77 tumors of the cortex (51 cases), the percentage belonging to tumors of non-motor regions was 17.5 per cent.; that of those belonging to motor regions (42 cases) was 54 per cent. of the whole, and 84 per cent. of the tumors of that region; while, finally, the probability that a tumor situated in the cortex would occasion

* The wide diffusion of the mechanisms for the motor-oculi nerve and the facial, which render their paralyses of little value in regional diagnosis, is probably correlated to the complex relations of these two nerves to the mechanisms of psychic existence, and their functions in the innumerable shades of facial expression.

some form or degree of paralysis is indicated by the relation of 51 to 77, or 66 per cent.

Centrum Ovale.—A much larger percentage of tumors remain latent in this region than in the cortex, as, for example, 36 per cent., instead of 25 per cent. (see Table V.). The absence of symptoms is to be expected when the tumor neither occupies nor affects bundles of fibres coming from the motor regions of the cortex. In the following table Ladame's and Bernhardt's cases are combined, and show to what extent tumors situated in non-motor regions may yet inhibit the mechanisms of the motor regions.

TABLE VI.—PARALYSIS WITH TUMORS OF CENTRUM OVALE.

Motor Regions.			Non-motor Regions.		
Seat.	Paralysis.	No paralysis.	Seat.	Paralysis.	No Paralysis.
Pars centralis anterior and posterior (Petres)......	61	16	Pars frontalis...... Pars occipitalis.... Temporal lobe..... Other parts........	37 10 2 ..	37 23 3 7
Total..........	61	16	Total..........	49	70

The paralyses which are associated with tumors of this region present nearly the same characteristics as do those associated with tumors of the cortex if they are near the surface: that is, they are liable to be monoplegic; but they resemble those of tumors of the internal capsule, if they approach the basal ganglion, in which case they may become completely hemiplegic, and may be followed by rigidity. Usually a long period of paresis precedes that of complete paralysis.

The percentage of cases of paralysis in tumors of the centrum ovale, whether calculated from the smaller number of cases in Table VI., or from the larger number in Table V., is about the same, viz., 54 per cent. in the first case, 56 per cent. in the second.

Basal Ganglia.—Tumors of the corpora striata, optic thalami, and lenticular nuclei occasion hemiplegias, which often differ from those of hæmorrhage in the same region, exclusively by their gradual rate of development. The paralysis is, however, sometimes monoplegic; thus, out of 41 cases, it was confined to the facial nerve four times, to the arm once, to the arm and facial once, and to the leg once. It is extremely remarkable that large tumors may exist in this region without causing any symptoms whatever. This is the rule for tumors limited to the thalamus or to the lenticular nucleus. Acute lesions, such as hæmorrhage in the latter ganglion, cause temporary hemiplegic symptoms, but these subside, probably because the function of the destroyed tissue is supplemented by that of other motor centres. But such temporary paralyses are not seen with chronic lesions, as, for example, tumors, unless these are complicated by an accidental hæmorrhage.

But tumors limited to the corpus striatum will certainly cause paralysis if they involve the anterior two-thirds traversed by the motor tract of the internal capsule. It is injury to this tract which determines the phenomenon of "late rigidity;" a phenomenon depending on the descending degeneration which reaches the spinal cord, and which, though so commonly seen after cerebral hæmorrhage, is not peculiar to that lesion, but only to the locality which it most frequently occupies.

If a tumor involve the posterior third of the internal capsule, whose fibres pass between the corpus striatum and the thalamus, it tends to destroy the sensory fibres which pass in this locality (Charcot, Veysière), and causes a hemianæsthesia in addition to the motor paralysis. This complication is therefore of great use in establishing the diagnosis of tumors of this region, which, from their encroaching tendencies are so liable to involve all parts of the internal capsule. It is possible that a transmitted irritation to sensory fibres has something to do with the high percentage of spasms observed in tumors of the basal ganglia (46 per cent., see Table V.). There were 24 cases of paralysis, with and without spasm, which is 58 per cent. of the whole number.

Peduncle.—As might be expected, tumors of this region cause hemiplegic paralysis in almost all cases (eighty per cent.). Together with the extremities, the facial nerve and also the hypoglossus are usually involved. The most characteristic circumstance, however, is the paralysis of the motor-oculi nerve by direct pressure upon its trunk, as it emerges in the interpeduncular space. The paralysis is on the same side as the tumor, that is, on the side opposite to the hemiplegia. The paralysis is usually total, in which case there will be unilateral dilatation of the pupil, ptosis from paralysis of the levator palpebræ muscle, and divergent strabismus from paralysis of the internal rectus. In other cases, one or more of these symptoms may exist alone. As the tumor grows larger it sometimes crosses the interpeduncular space, and compresses the nerve on the opposite side. This important symptom existed in seven out of the ten cases of Ladame and Bernhardt. It is not, however, absolutely pathognomonic of lesions of the peduncle; for it results, with exactly the same forms, from every tumor of the interpeduncular space; thus, from those springing from the base of the cranium.

Corpora Quadrigemina.—Tumors of these bodies lie outside of the direct cerebro-spinal motor tracts, and thus produce much less definite motor symptoms. Some degree of paralysis existed in 5 out of 13 cases; in 1, paresis of the arm and facial nerve; in 2, a unilateral facial paresis; in 1, paresis of one leg; and in 1, paresis of one-half of the body.

On the other hand, the motor-oculi nerve seems to be paralyzed as often as in the case of tumors of the peduncles; a fact which might be expected from the proximity of the corpora quadrigemina to the nuclei of the nerves, which lie immediately below them. In 14 cases, divergent strabismus existed in 8 (five cases of Bernhardt, three related by Nothnagel). In one other case, the abducens was paralyzed, so that internal strabismus existed (Gowers, *Lancet*, 1879).

Cerebellum.—Absence of true motor paralysis, taken together with impairment of the power of equilibration, is highly characteristic of tumors of the cerebellum. Out of a total of 165 cases, only 38 showed any kind of paralysis (23 per cent.). This is almost the proportion in which the symptom is absent in tumors of the cerebral cortex. Excluding the cerebellum and corpora quadrigemina, the probabilities of paralysis with brain tumor are expressed by the percentage 89, while for the cerebellum and corpora quadrigemina alone, the percentage is only 24.

Tumors of either lateral lobe of the cerebellum cause of themselves no motor symptoms, even ataxic, and may be completely latent. Out of the 38 cases of paralysis the tumor occupied the middle lobe of the cerebellum in 4; in 5, one of the peduncles; in 15, though mainly situated in a lateral lobe, it extended into the middle lobe, or else compressed the pons or medulla.

The facial nerve may be affected either by an isolated, by an alternating, or by a hemiplegic paralysis, in the rare cases in which hemiplegia occurs. The lesion is never really of cerebellar origin, but always secondary to encroachment upon the pons or medulla.

Pons Varolii.—In this locality tumors produce the most extensive and also the most complex combinations of paralyses. They are occasionally paraplegic, and not infrequently they become, little by little, generalized throughout the four limbs. This creeping generalization is highly characteristic of tumors of the pons. On the other hand, only cranial nerves may be affected.

Case (Wernicke, *Archiv. f. Psychiat.*, Bd. vii.): Patient aged fifty-eight years. In July, headache, diplopia; difficulty in opening and shutting mouth. By end of August, paralysis of left facial nerve, including upper branches; rigidity of left masseter; eyes persistently deviated toward the right; diminished sensibility of face and head on the *right* side, that is, on the side opposite to the facial paralysis. Death occurred in October without further motor affection. Section discovered a tumor on the floor of the fourth ventricle, on the left side of the middle line. Associate nucleus of facial and abducens

completely destroyed; left facial nerve nucleus, as also part of the fibres of the right trigeminus, destroyed.

After the frequent generalization of the paralysis, the remarkable symptoms of pontine tumors are: 1. The coexistence of hemiplegic paralysis of the extremities with paralysis of one or more cranial nerves on the opposite side of the body; alternate paralyses. 2. The occurrence of a *persistent* conjugate deviation of the eyes, thus distinguished from the same symptom in lesions of the hemispheres, where it is always transitory. To these positive symptoms may be added an important negative characteristic, namely, the nearly complete absence of local irritative symptoms, and, to an even more marked degree, of general convulsions. The alternate paralyses are produced by tumors in the lower part of the pons, which injure the nerve-nucleus or compress the nerve-trunk on the side on which they are situated, and injure the general motor tracts of the limbs previous to their decussation, so that the resultant hemiplegia follows the usual law for cerebral paralysis, and appears on the side of the body opposite to the lesion. When the tumor occupies the upper segment of the pons, anterior to the cerebral peduncles, the facial paralysis will be on the same side as the limbs, since it depends not on a lesion of the nucleus or nerve-trunk, but on one involving the central fibres after their decussation.

In the most typical cases, all the branches of the facial are paralyzed, including those innervating the orbicularis palpebræ. The eye cannot be closed, and the patient presents the appearance of Bell's paralysis. The electric excitability of the nerve may then be diminished. However, neither of these last conditions is invariable, even when the paralysis is alternate.

Double facial paralysis is extremely rare. It is lesions of the pons which have furnished the explanation of the remarkable phenomenon—conjugate deviation of the eyes—which for a long time puzzled pathologists. This deviation implies paralysis of the abducens nerve of one side, supplying the external rectus, and coincident paralysis of a branch of the motor-oculi nerve supplying the internal rectus on the opposite side. The apparent remoteness from each other of the nuclei of origin of these two nerves rendered this phenomenon extremely difficult to understand, until the discovery was made, in the pons, of a common nucleus, which unites fibres of the abducens with fibres from the lower nucleus of the motor oculi on the opposite side. Destructive lesions of this associate nucleus are followed by a permanent conjugate deviation, as in the case (Wernicke) above quoted. It becomes evident that the transitory deviations of the eye, frequently seen immediately after an attack of hæmorrhage into any part of the brain, are due to a remote shock propagated to this same nucleus.

The abducens nerve is not infrequently paralyzed alone, causing a converging strabismus of the affected eye.

Isolated paralysis of the motor-oculi nerve is much more rare, and is seen only when the tumor or its influence extends above the pons into the cerebral peduncles, or above them to the nerve nuclei. Ptosis, from isolated paralysis of the levator palpebral branch, has sometimes been observed alone, and, so far, in cases of tumors, but not in those of any other lesion. This symptom would, therefore, be useful in differential diagnosis.

Paralysis of the hypoglossus is not rare. It is indicated by an impairment of the voluntary movements of the tongue and by disturbance of speech, anarthria. This paralysis alternates with that of the extremities. It is distinguished from progressive bulbar paralysis by absence of atrophy of the tongue.

The motor branch of the trigeminus is sometimes paralyzed, more often irritated, causing, in the latter case, spasmodic trismus or clonic convulsions of the muscles of mastication.

Difficult deglutition is also sometimes present, but does not seem to be attributable to paralysis of the pharynx muscles, but rather to be a secondary consequence of paralysis of the tongue and of certain muscles innervated by the facial nerve, the styloglossus, digastricus, and stylohyoideus (Nothnagel).

The following table exhibits the various combinations of paralyses, which have been observed with tumors of the pons.

TABLE VII.—MOTOR PARALYSES WITH TUMORS OF PONS (56 CASES).

Cranial nerves alone.		Limbs alone.		Combination of limbs and cranial nerves.		No motor symptoms.
3d nerve	2	Hemiplegia	7	*On same side.*		
7th nerve	3	Paraplegia	3	Hemiplegia and 7th nerve	4	
3d and 6th nerves	2	Four extremities	2	*Alternate paralysis.*		
6th and 7th nerves	3	Arm alone	1	Hemiplegia and:		
7th and 12th nerves	1			3d nerve	2	
3d, 7th, and 12th nerves	1			6th nerve	3	4
3d, 5th, 7th, and 12th nerves	1			7th nerve	4	
				3d and 6th nerves	1	
				3d and 7th nerves	3	
				6th and 7th nerves	5	
				3d, 6th, and 7th nerves	1	
				3d, 5th, 7th, and 12th nerves	1	
				3d, 6th, 7th, and 12th nerves	1	
Total	13	Total	13	Total	26	4

The number of cases in which the cranial nerves or those of the limbs were paralyzed independently of each other is, in this collection of cases, exactly equal. The number of cases of combined paralyses is just double that of either of the classes of isolated paralyses. Among the cranial nerves, the liability of the facial is evidently the greatest; it was affected, alone or in combination, twenty-four times; the abducens sixteen times.

Medulla.—In this region the liability to paralysis again diminishes. Tumors of the medulla are not infrequently confined to the floor of the fourth ventricle, so that the motor tracts and nuclei are both left uninjured. In this case, the patient escapes all paralysis; indeed, he often remains with singularly few symptoms for the subject of an organic disease seated so near to vital nerve-centres. Out of 30 cases, 12, or nearly half, remained free from motor symptoms. In one case, so far unique (Erichsen, *Petersb. Med. Zeitschr.*, 1870), a bilateral paralysis of the vocal cords was noted, due to lesion of the accessory nerve.

TABLE VIII.—MOTOR PARALYSES WITH TUMORS OF MEDULLA (30 CASES).

Cranial nerves alone.		Extremities.		Combination.		Negative.
3d nerve	2	Hemiplegia	1	Hemiplegia and 6th nerve	1	
7th nerve	2	3 extremities	1	*Same side.*		
3d and 7th nerves	1	Paraplegia	2	Hemiplegia and:		
7th and 11th nerves	1	General	2	6th nerve (alternating)	1	
5th, 6th, and 7th nerves	1			3d, 6th, and 7th nerves	1	
				3d, 7th, and 12th nerves	1	12
				7th and associated 3d and 6th nerves	1	
Total	7	Total	6	Total	5	12

Ataxia.—This third form of motor lesion is principally seen with tumors of the cerebellum and corpora quadrigemina; the latter, possibly from the connection of these bodies with the cerebellum through the superior cerebellar peduncles. In the pons and medulla, the advent of paralysis is often preceded for some time by a staggering or reeling gait "like a drunkard's." This same symptom is very conspicuous in tumors of the cerebellum, and, when associated with the negative symptoms of absence of motor or sensory paralysis, points very strongly to tumors of this region. For the development of the symptom, however, it is essential that the middle lobe be involved or indirectly affected; tumors limited to a lateral lobe are characteristically latent.

Forced movements, or inclinations of the body or head to one side or the other, are sometimes associated with

tumor in a lateral peduncle on the corresponding side. A tendency to fall forward or backward has been associated with the situation of the tumor in the anterior or posterior extremity of the upper or lower processus vermiformis (middle lobe).

Lesions of Sensibility.—With the exception of headache, already described as a diffuse symptom, alterations of sensibility are very much less prominent in the symptomatology of tumors than alterations of motility.

It is evident from this table that, in the cortex, the seat

Table IX.—Lesions of Sensibility with Brain Tumors.

Seat.	With Motor Paralysis.						Without Motor Paralysis.						Negative.	No. of cases. Total percentage lesions of sensibility.
	Unilateral.		Double.		Trigeminal.		Unilateral.		Double.		Trigeminal.			
	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.		
Cortex (57 cases):														
Central gyri	6	7	....	....	....	....	1	....	....	....	....	....	11	14 = 56
Parietal gyri	1	8	....	....	....	....	....	1	....	....	....	....	12	5 = 29
Frontal gyri	....	....	....	....	....	....	1	....	....	....	....	....	9	1 = 10
Temporal	....	2	....	....	....	....	....	1	....	....	....	....	1	3 = 75
Occipital	....	....	....	....	....	....	....	....	....	....	....	....	1	0 = 0
Entire cortex	8	15	....	....	....	....	....	....	....	....	....	....	34	23 = 40
Centrum ovale (124 cases)	5	14	....	....	....	....	....	....	....	....	....	....	105	19 = 15
Basal ganglia (39 cases)	1	5	....	....	....	....	....	2	....	....	....	....	81	8 = 25
Peduncle (10 cases)	1	3	....	....	....	....	....	....	....	....	1	....	5	5 = 50
Pons (51 cases)	Same side, 1	10	....	....	2	....	....	....	....	....	....	....	24	27 = 52.5
	Opp. side, 7	....	....	2	....	5	....	....	....	....	....	....		
Medulla (30 cases)	4	5	....	2	1	1	....	1	....	....	....	....	16	14 = 46
Cerebellum (167 cases)	2	7	....	1	1	4	5	5	....	....	....	....	142	25 = 14.5
Corp. quad. (13 cases)	1	....	....	....	....	....	1	....	....	....	....	....	11	2 = 15
Total (491 cases)	30 = 6% of all cases.	59 = 12%	....	5 = 1%	4 = 0.8%	10 = 2%	8 = 1.2%	8 = 1.6%	....	....	1	....	368	......

Percentage of lesions of sensibility in all cases equals twenty-five.

of sensibility coincides with the seat of mobility. Pain or anæsthesia rarely exists without paralysis, or except in connection with tumors situated in the motor zones. The liability to pain, other than headache, with tumors of the centrum ovale, is very slight (5 cases out of 124).*

It has already been pointed out that tumors of the basal ganglia will cause hemianæsthesia in paralyzed limbs, provided they involve the bundle of fibres which pass in the posterior third of the internal capsule; otherwise they will not be attended by lesions of sensibility. The table, therefore, expresses the probabilities of this precise situation, in giving the proportion of cases of pain or anæsthesia as 8 out of 39, or twenty per cent.

The highest percentage is with tumors of the pons, and the next highest, if the few cases of tumors of the peduncles of the cerebrum be excluded, is with those of the medulla. In these places occur pain and anæsthesia in the facial range of the trigeminus, symptoms almost peculiar to such tumors. When similar symptoms are excited by tumors of the cerebellum, it is only because the pons or medulla has been compressed. Trigeminal neuralgia or anæsthesia is, like cramp or paralysis of the masticatory muscles, a most important symptom for helping to localize a tumor in the posterior cranial fossa. It is noticeable (see Table) that trigeminal anæsthesia has hitherto been observed on the side opposite to the paralysis, while anæsthesia of the extremities has nearly always existed on the same side.

The cerebellum and corpora quadrigemina show the same minimum liability to lesions of sensibility as they do to motor paralysis. Their percentage, almost alike for the two cases, is, however, not lower than that of the centrum ovale.

Comparison of the latter with the cortex on the one hand, and with the peduncle, pons, and medulla on the other, seems to indicate that sensation is affected either by lesion of terminal nerve-cells (as in the cortex), or of very concentrated bundles of nerve-fibres. When these are widely disseminated, as in the centrum ovale, so that a few can only be involved in the lesion, motor power may, nevertheless, suffer extremely, while sensibility remains intact.

* The percentage of headache, however, was sixty-six, the highest after the cerebellum and rare cases of corpora quadrigemina. The liability to headache, from distention of the dura mater, is constantly seen to bear no proportion to perversions of sensibility due to lesion of sensory tracts or centres.

Lesions of the Special Senses.—*Vision.*—Disturbances of vision are extremely frequent as symptoms of brain-tumor, and are of three kinds: First, atrophy of the optic papilla as a consequence of choked disk, and therefore as a remote consequence of increased intracranial pressure; second, deviations of the eyeball or eyelids from isolated or combined paralyses of the nerves supplying the ocular muscles, the third, sixth, and seventh; third, finally amblyopia or amaurosis, resulting from direct affection of the optic nerve in its course through the cranium, or at its cerebral centres, the mode of development being therefore almost precisely analogous to that of paralysis of any other nervous tract by direct compression. The first two kinds of ocular defect have been sufficiently described; the third comprises two different kinds of lesions, those affecting (by compression) the optic tract or chiasma, and those which affect the optic stations at the posterior extremity of the thalami or at the corpora quadrigemina, or else at the final visual centres of the cortex.

The optic nerve or chiasma is liable to compression from tumors arising from the base of the cranium, or from the hypophysis, and also from tumors of the peduncle; an acute descending optic neuritis, with atrophy of the papilla, is usually excited. When one tract or one side of the chiasma is compressed, hemiopia results, a phenomenon dependent on the semi-decussation of nerve-fibres which takes place in the human chiasma. Thus pressure on the right side beyond the chiasma, of such a nature as to injure the fibres of one tract, will abolish vision in the right half of both eyes. A tumor in front of the chiasma may cause temporal hemiopia of both eyes, since it injures fibres coming from the nasal half of both eyes. There is no way in which a double nasal hemiopia can be produced by tumors at the base of the brain.

Tumors of the thalamus might be expected to affect the sight from lesion of the corpus geniculatum, with its branch to the optic tract. As a matter of fact, however, blindness is not very common from tumors of this locality—only 5 cases out of 26 (19 per cent.). Tumors of the corpora quadrigemina, however, have an immensely large proportion of cases. Out of 11, 9 showed either amblyopia or amaurosis, 5 with and 4 without choked disk (81 per cent.).

Visual defects from lesions of the cortex are extremely interesting in connection with two physiological problems, viz., the question of a second decussation of optic nerve-

fibres in the cerebrum (Charcot), and that of the localization of the mental centre of vision. This centre was placed by Ferrier at the angular gyrus, as an inference from direct experiment upon the brain of monkeys. But Exner, on the authority of four cases of lesion reaching to the cortex, of which two were tumors, places the visual centre in the first and second occipital gyri—the cuneus and adjacent part of the lobulus quadratus.

Case (Gowers, *Lancet*, 1879): Visual hallucinations of a peculiar nature, associated with some degree of amblyopia, affecting both eyes, but more markedly the left. Tumor occupying first and second occipital gyri, posterior half of superior and inferior parietal lobes, the cuneus, and a part of the lobulus quadratus.

Case (Jastrowitz, *Centralbl. für prakt. Augenheilkunde*, vol. i., 1877): Paralysis of both right extremities and facialis; aphasia, with agraphia; hemianopsia dextra. Tumor of the left occipital lobe, principally in the occipital gyri and the præcuneus.

Case (Pooley, *Arch. f. Augen. und Ohrenheilk.*, Bd. vi.): Together with various characteristic symptoms of brain tumor in a syphilitic man, extensive binocular hemianopsia. Tumor in posterior lobe of left hemisphere, surrounded by extensive zone of softening. Left thalamus completely softened.

A tumor of one hemisphere may thus cause double hemiopia, a single or double amblyopia or amaurosis, and visual hallucinations of various kinds. The double hemiopia from unilateral lesion, has been interpreted as a proof that, arrived at the cerebral hemispheres, optic fibres which had decussated in the chiasma, recrossed to the opposite hemisphere, thus finally arriving at the same side as the retina, from which they started. Hemiopia is habitually unaccompanied by choked disk. It is indeed rare as a symptom of tumor, and has been principally studied in connection with other lesions.

Six cases of amblyopia and amaurosis have been observed with cortical tumors, unaccompanied by choked disk. These are all to be attributed to a lesion of the visual centre; and, when located in the frontal lobe, the lesion must be regarded as indirect. The amaurosis or hemiopia, with tumors of the centrum ovale (39 cases, or 31 per cent.), probably always implies a transmitted lesion of the cortical visual centre. Of the two cases of hemiopia, referred to in table X., one is used by Exner and Nothnagel as documentary evidence in support of the theory of a visual centre in the cortex of the occipital lobe, but it is placed by Bernhardt among the tumors of the lobes. The total percentage of blindness is higher with tumors of the cerebellum than with those of any other locality, except the corpora quadrigemina. Out of 91 cases there are 41 with some degree of blindness (45 per cent.). Of these, 23, or nearly half, are without choked disk; the blindness being therefore due to the direct action of the tumor upon some visual centre. It seems most probable that the centre affected is that of the corpora quadrigemina; the influence being transmitted through the superior cerebellar peduncles. The high percentage of blindness in the two localities so especially liable would be shown, therefore, to have the same significance. Tumors of the pons and medulla also determine amaurosis otherwise than by choked disk, through direct upward pressure upon the corpora quadrigemina. The direction of the transmission is the same as for the upper (unassociated) nucleus of the motor-oculi nerve, which lies just below the corpora quadrigemina. Out of a total of 51 cases for medulla and pons together, there are 14 cases of amblyopia or amaurosis, or 27 per cent.

TABLE X.—LESIONS OF VISION (IN 369 CASES).

Seat.	With Choked Disk.					Without Choked Disk.					Negative.	
	Total No. of cases.	Hemiopia.	Amblyopia.	Amaurosis.	Per cent.	Hemiopia.	Amblyopia.	Amaurosis.	Per cent.	Total per cent.	Choked disk.	No choked disk.
Central gyri	......	......	......	1	......	......	......	......	......	......	3	20
Parietal	......	......	......	1	......	......	3	2	......	......	......	12
Frontal	......	......	......	......	......	......	1	......	......	......	......	8
Occipital	......	......	......	......	......	......	......	......	......	......	......	3
Temporal	......	......	......	1	......	......	......	......	......	......	1	......
Entire cortex	56	......	......	3	5.0	......	4	2	10.5	16.0	4	43
Centrum ovale	124	......	4	11	12.0	2 {1 occipital. 1 frontal.}	9	13	19.0	31.5	12	70
Basal ganglia	26	......	......	......	......	......	4	1	19.0	19.0	2	18
Cerebral peduncle	10	......	1	......	......	......	2	......	......	......	......	7
Pons	30	......	1	3	13.0	......	6	......	20.0	33.0	2	18
Medulla	21	......	......	......	......	......	1	3	......	19.0	2	15
Cerebellum	91	......	4	14	19.5	......	9	14	25.0	45.0	11	39
Corpora quadrigemina	11	......	2	3	45.0	......	3	1	36.0	81.0	1	1
Total	369	......	12	34	......	......	38	34	......	......	34	211

Total lesions of vision = 118 in 362 cases = 31 per cent.

To judge from this table we should infer that the chances of amaurosis in brain tumor were exactly equal, whether choked disk existed or not; but that the chances of amblyopia were three times as great without the choked disk as with it. This probably means that if choked disk occur, the impairment of vision which may have been initiated independently of it, by the direct influence of the tumor, will rapidly increase to complete blindness; whereas, without this local complication, the visual defect may for a much longer time, or even altogether, remain partial and incomplete.

Hearing, Taste, and Smell.—All these special senses together are less frequently affected than is vision alone. Out of a total of 369 cases of brain tumor, lesions of vision existed in 118, or 31 per cent. But in a total of 554 cases (which include Ladame's), hearing, taste, and smell are altogether only affected in 67, or 12 per cent. In 46 out of these 67 cases the patient suffered from either tinnitus or deafness, the latter rarely complete. In 26 out of the 46, thus in more than half, 56 per cent., the tumor was situated in the cerebellum. This fact tends to confirm, if need be, the recent anatomical demonstration, which traces the central fibres of the acoustic nerve to the cerebellum. By far the highest percentage of disturbance of hearing is exhibited by tumors of the corpora quadrigemina. It is singular that reports of tumors of the frontal lobes so rarely mention symptoms indicating lesion of the olfactory tracts. It would seem that an indirect influence or diffused pressure is insufficient to pervert the sense of smell; this is only affected by actual disorganization of the tracts. In a few cases, anosmia, associated with frontal headache, psychic disturbance, and absence of motor or sensory paralysis, has been a valuable symptom which correctly pointed to tumor in the frontal lobes. But anosmia has also been observed with a tumor of the supramarginal convolution. The sense of taste, though controlled by two medullary nerves, usually escapes injury, even with tumors of the medulla.

TABLE XI.—LESIONS OF SPECIAL SENSES (561 CASES—369 FOR VISION).

Seat of tumor.	Hearing.	Per cent.	Taste and smell.	Per cent.	Vision.	Per cent.
Cortex (59 cases)............	1	1.5	4	7.0	9	16.0
Cerebrum ovale (192 cases)..	8	4.0	3	1.0	39	31.5
Basal ganglia (41 cases).....	2	4.0	..	..	5	19.0
Peduncle (3 cases)...........	..	..	..	..	3	..
Corp. quad. (13 cases).......	4	30.0	..	..	9	81.0
Cerebellum (167 cases)......	26	15.0	2	1.0	41	45 0
Pons (56 cases)..............	3	5.0	9	16.0	10	33.0
Medulla (30 cases)	2	6.0	3	10.0	[illegible]	19.0
Total	46	8.0	21	3.5	118	21.0

Disturbances of Language.—These symptoms, formerly confounded either with symptoms of mental alienation, or else with difficult articulation caused by tongue paralysis, have, during the last two decades, acquired an extreme interest and importance. The discovery that a patient may retain other mental conceptions, yet lose that of spoken or written speech; furthermore, that the generic defect may be again resolved into several modes, namely, aphasia proper, agraphia, alexia, and simple "word-blindness;" this discovery has immensely widened the horizon of ideas in regard to the physiology and pathology of the brain, and has enriched the symptomatology of all brain diseases, including tumors.

From the foregoing analysis of the causation and especial probabilities of diffuse and focal symptoms, it is possible, in a given case, to answer the two questions: first, Is there a brain tumor present? second, In what part of the brain is it situated?

I. EXISTENCE OF BRAIN TUMOR.—Although a tumor of the brain may develop during either childhood or adolescence, let us suppose it to have begun its growth in an individual of middle age, who perhaps has shown a tendency to tuberculosis. In such a case we can assume that the clinical picture will be somewhat like the following: For weeks or months the patient will suffer from persistent or periodic headache, usually localized at one spot; the pain is peculiarly severe, and is increased by percussion. After a time there will be attacks of vomiting, which sometimes coincide with the most intense paroxysms of pain, and sometimes do not. These attacks, furthermore, seem to bear no relation to the character of the food taken, or to the condition of the digestive organs; they do seem, however, to be dependent upon changes in the position of the body, as, for example, from the recumbent to the upright position. As in the case of sea-sickness, the attacks are sometimes incoercible. They are associated with vertigo; and, in turn, the vertigo may occur independently of either the headache or the vomiting. It is apt to occur at intervals, and is often chronic in character. After the symptoms which have just been enumerated have lasted for a variable length of time, the patient's gait becomes uncertain; he reels or staggers, or shows a tendency to fall forward or backward. This tendency sometimes increases until complete loss of equilibration renders the patient unable to stand, though he may be entirely free from paralysis. The muscles of one side of the face or of one arm begin to twitch, or even to be agitated by clonic spasms, which may either persist all the time, except during sleep, or else may recur in periodic paroxysms, followed by paresis, gradually increasing to paralysis in the same muscles or in others, *e.g.*, in the arm or leg, after twitching of the muscles of the face. The progress of the paralysis is apt to be interrupted by one or more convulsions, or by attacks of apoplexy or of loss of consciousness; or one of these may usher in the first signs of paralysis, which, at the outset, may be complete, facial, monoplegic, or hemiplegic. Paræsthesia or anæsthesia is next likely to manifest itself in the paralyzed limbs, or on the side of the face opposite to these. Afterward the symptoms succeed one another in about the following order: alternate paralysis of cranial nerves and extremities; deviations of the eyeballs, isolated or conjugate; dilatation of the pupils, ptosis, much more rarely appearance of Bell's paralysis; occurrence at this time of diplopia, hemiopia, or amblyopia, gradually increasing to complete amaurosis; much more rarely deafness or anosmia, and the discovery of choked disk before or after the development of ocular symptoms; progressively increasing modification of psychic character—at first marked irritability, then impairment of mental powers, loss of memory, apathy or hallucinations, maniacal excitement, and melancholic insanity; before or at the same time with the appearance of this mental change, there will be lesions of speech, dysarthria, aphasia, or word-blindness, the two latter often suddenly developed, as after an embolus, the first proportioned to the degree of tongue paralysis, and gradual. A patient presenting the foregoing assemblage of symptoms, all progressively increasing, has, with very great probability, a brain tumor. In addition is to be noted the freedom from pyrexia, and usually from changes in the rhythm of either pulse or respiration. The gradual, sometimes rapid, emaciation, the fact that acute accidents, though often followed by an exacerbation of existing symptoms, or even by the first appearance of new ones, have nearly always been preceded by others which have established themselves insidiously, are circumstances important to the diagnosis.

This being the general picture of the disease, individual cases are framed by the special emphasis of one or more symptoms, or the obliteration of others. The individual peculiarities depend upon (1) the locality of the tumor, (2) upon its rate of growth, (3) upon its complications, (4) and, only to a very slight extent, upon its nature.

Peculiarities due to Locality.—These may be divined approximately from such an analysis as has already been given of the symptoms proper to lesions of each given locality. The *a priori* judgment must, however, be modified in view of the tendency of tumors to encroach, in growing, upon territories adjoining their original seat, and also in view of the frequent diffusion of their influence beyond any situation which they may occupy.

The following summary of symptom groups is arranged in the order of characteristicness. It does not correspond to the order of frequency of locality, which, as indicated by the combined tables of Ladame and Bernhardt, would be as follows:

Centrum ovale.........................	192	= 29	per cent.
Cerebellum............................	167	= 27	"
Cortex	74	= 11	"
Pons..................................	56	= 8	"
Basal ganglia..........................	36	= 5	"
Medulla	30	= 4	"
Corpora quadrigemina..................	13	= 2	"
Cerebral peduncle......................	10	= 1	"
Extra cerebral (including pituitary gland)	71	= 11	"
	649		

1. *Tumor of Cerebellum involving Middle Lobe.*—Vertigo, vomiting, and headache, early, severe, and prolonged; latter often occipital; epileptiform convulsions of great violence, but not often repeated; choked disk early, preceding amaurosis, but also followed by this; deafness; ataxic loss of equilibrium, tendency to fall forward or backward; absence of motor or sensory paralysis; intelligence clear till toward the end, when apathy gradually deepens to coma.

2. *Tumor of Lateral Lobe of Cerebellum pressing on Pons.*—Similar symptoms to 1, but complicated late in the disease by hemiplegia or hemianæsthesia, or both, or by alternate paralysis. Distinguished from pontine tumors by marked ataxia preceding paralysis.

3. *Tumor of Pons, Lower Half.*—Uncertainty of gait, rather than ataxia, succeeded by isolated paralysis of third, or sixth, or seventh, or twelfth nerve, not preceded by symptoms of irritation in the muscle which it supplies; or else alternate paralysis, passing into incomplete paraplegia or general paralysis; permanent conjugate deviation of the eyes; amaurosis in a third, choked disk in a fifth, of the cases; entire absence of convulsions; headache, vomiting, and vertigo milder than in cerebellar tumor, or absent, but intelligence affected in half the cases.

4. *Tumor of Upper Part of Pons.* — Combination of symptoms proper to cerebellum and pons, as lobe of cere-

bellum is frequently compressed. Isolated rather than conjugate paralysis of the third nerve; paralysis of the facial on same side as hemiplegia; irritation of the trigeminus, sometimes of motor root, occasioning trismus; or of sensitive root, causing neuralgia on the side opposite to the hemiplegia. Sudden death is especially frequent in tumors of the pons.

5. *Tumor of Cerebral Peduncle, or of Interpeduncular Space.*—Diffuse symptoms mild or absent; complete hemiplegia, including buccal branches of facial, usually accompanied by hemianæsthesia on same side; paralysis of motor-oculi nerve, causing divergent strabismus on side opposite to hemiplegia, this frequently passing over to opposite side.

6. *Tumor of Cerebral Cortex, or Upper Part of Centrum Ovale.*—Epileptiform convulsions, frequently repeated, but often brief and of moderate severity. Headache usually frontal, possibly on one side, severe at first, apt to gradually lessen; choked disk infrequent, vomiting and vertigo much less marked than with tumors of posterior fossa. Spasmodic twitchings or clonic convulsions, in face or limb muscles, followed by dissociate or monoplegic paresis increasing to paralysis, rarely accompanied by anæsthesia. Paralysis of tongue, hemiopia, or peculiar visual hallucinations, sometimes seen when tumor is in occipital lobe, but also (once at least) when in frontal. Aphasia, especially in connection with right hemiplegia. Word-blindness sometimes without paralysis, the tumor being in the temporal lobe. Psychic disturbance in about half the cases (49 per cent.).

7. *Basal Ganglia, or Lower Part of Centrum Ovale.*—Complete hemiplegia, often followed by rigidity, thus resembling the hemiplegia of hæmorrhage, except in regard to the more gradual development of the former. Sometimes associated with complete permanent hemianæsthesia. Often complicated, late in the disease, with symptoms of intraventricular effusion; thus, for example, there are convulsions, retraction of the head, loss of consciousness, slow pulse, contracted pupils, as in acute hydrocephalus.

8. *Corpora Quadrigemina.*—Individual cases can with difficulty be distinguished from tumors of the cerebellum. In the calculation of probabilities, however, the much greater frequency of cerebellar tumors (twenty-seven per cent. of the whole number as compared with two per cent.) is not to be forgotten. With tumors of the corpora quadrigemina, however, the percentage of headache, though high, is less so than with those of the cerebellum; the percentage of vomiting is higher; convulsions seem to be so rare that their presence in a doubtful case would turn the scale against the corpora. The proportion of cases of choked disk is high, and of amaurosis, as also of psychical defect, higher than for tumors of any other locality (eighty-one per cent. of cases are amaurotic; seventy-seven per cent. present psychic symptoms). Divergent strabismus from paralysis of the motor oculi is sometimes present, and is then very characteristic.

9. *Medulla.*—All symptoms ill-defined; they resemble those of tumors of the pons. Dysarthria, dysphagia, and irritation of the cardiac and respiratory centres are more frequent. Paralysis of the vocal cords has been observed in a single instance.

Besides the localities already mentioned, the clinician must always inquire whether the tumor whose existence is suspected does not spring from the cranial bones or the dura mater lining them. Tumors of the anterior, middle, and posterior cranial fossæ excite symptoms which approximately resemble those belonging to the cerebral organs reposing in the same spaces.

Anterior Fossa.—This comprises two regions, the sella turcica, with the pituitary gland and the optic chiasma, and the part anterior to this, upon which repose the frontal lobes of the hemispheres. In the latter position tumors may cause exophthalmia on one or both sides. Apart from this, the characteristics are similar to those of tumors of the frontal lobes. Hemiplegia, spasms, and epileptiform attacks are in the background, while headache and vomiting play about the same part that they do in other tumors. It is asserted that the most notable symptom is psychical in character, viz., a peculiar childish alteration of character.

Sella Turcica.—Although tumors in this region involve the pituitary gland, it is impossible to assign any special symptoms to lesions of that organ, whose functions are so entirely unknown. Patients suffer from severe frontal headache, but they manifest a striking apathy and drowsiness, without marked motor or sensory paralysis, or any disturbance of speech. From generalized pressure on the chiasma results double progressive amblyopia or amaurosis.

When the tumor bears other relations to the chiasma, it produces some species of hemiopia. If anterior to the chiasma, it produces a double temporal hemiopia, from compression of the fibres coming from the inner half of each retina. On one side of the chiasma the tumor would only affect the outer fibres of one retina, or, if situated, further back, so as to compress an entire optic tract after decussation—that is, all the fibres from the homonymous parts of the two retinæ, as, for example, the right or the left halves of both eyes—it would produce homonymous hemiopia.

Middle Fossa.—The most characteristic symptoms of a tumor of the middle fossa depend upon lesion of the trigeminal nerve. Thus, there may be unilateral anæsthesia of the face, unilateral weakness of the masticatory muscles, and, finally, if the Gasserian ganglion be injured, neuro-paralytic keratitis of one eye. Through the medium of the chorda tympani branch of the trigeminal the sense of taste may also be paralyzed.

In addition to these most characteristic paralyses, there is frequently paralysis of the motor-oculi nerve, of the facial (five times out of nine), and of the acoustic nerve—the latter usually by penetration of the tumor into the internal auditory canal of the petrous bone. With the facial paralysis there is degenerative electrical reaction. With these marked positive symptoms are associated certain negative symptoms—absence of motor or sensory paralysis in the extremities, absence of convulsions, absence or mildness of the headache or the vomiting.

Posterior Fossa.—Tumors of this region cannot with any certainty be distinguished from those of the medulla, pons, or lower segment of the cerebellum. In one case a peculiar conjugated deviation of the eyes has been observed, the right eye turning upward and outward, the left inward and downward. This deviation recalls Magendie's experiment of section of the right lateral peduncle of the cerebellum; and it is probable that this organ was involved in the tumor. Amaurosis or amblyopia exists in one-third of the cases; that is to say, even more frequently than in tumors of the cerebellum. But, in any individual case, this symptom can serve no purpose of diagnosis.

Parts of Brain in which Tumors are most Frequently Latent.—Complete latency implies absence of all symptoms; incomplete latency implies absence of focal symptoms only. The localities in which the latter condition is characteristically observed are also those in which tumors may most often be completely latent. These localities are: The temporal, occipital, or even, but less easily, the frontal lobes of the cerebral hemispheres, provided the central gyri are not indirectly affected; the parts of the centrum ovale corresponding to these regions, and hence untraversed by fibres from the pyramidal tract; the lateral lobes of the cerebellum, the thalamus opticus, and the lenticular nucleus. Finally, it is possible that in any portion of the brain a tumor may remain latent, providing it grow slowly enough.

Differential Diagnosis.—The epileptiform convulsions dependent upon cerebral tumor differ little or not at all from those of functional epilepsy. They are, however, often slighter, or at least the loss of consciousness is much less profound. The headache, on the contrary, is chiefly noticeable for its extreme intensity and persistence, in which respect it exceeds even nervous headaches. The vomiting is also noticeable for its violence, and for the absence of any other symptoms of disordered digestion, such as furred tongue, epigastric uneasiness, etc. The diagnosis in regard to these symptoms ultimately depends

on their combination, and on their association with paralysis or with psychical symptoms. Conversely, the psychical symptoms of tumor are distinguished from pure mental alienation chiefly by the existence of these physical signs; also by their greater vagueness, which renders precise psychiatric classification difficult or impossible.

It is by no means always easy to decide whether a patient with cerebral symptoms is suffering from a diffused or focal disease, and in the diagnosis of tumor it is necessary to exclude meningo-encephalitis, progressive general paralysis, chronic basal meningitis, hydrocephalus, cerebro-spinal form of multiple sclerosis, and locomotor ataxy.

Tubercular meningo-encephalitis, which easily lasts three months, has, it must be remembered, a duration not inferior to that of many tumors, and many of the symptoms are identical: violent headache, convulsions, vomiting, neuritis optica, changes of character, monoplegic paralysis, and spasms. In the diffused inflammation, however, these paralyses are transient and variable, a condition sometimes, but rarely, seen in tumor. The disease, moreover, is always attended by more or less fever, by more marked variations in the pupils, by a slow, hard pulse, by obstinate constipation, by retraction of the abdomen, and by vaso-motor symptoms. When a tubercular tumor is associated with diffused inflammation, it is masked by the symptoms characteristic of the latter.

A tumor of the medulla may especially simulate progressive general paralysis by producing a diffused paresis without distinct paralysis, embarrassment of speech, depression of mental power, headache, and unequal dilatation of the pupils. A tumor, however, is indicated by the occurrence of amaurosis, convulsions, vomiting, localized paralyses; while the diffused disease is characterized by the appearance of ambitious delirium, and by the peculiar trembling of the lips. Tumors of the sella turcica may be closely simulated by chronic basal meningitis, which is most frequently situated in exactly the same locality, and also involves the same nerves. It is distinguished by the occurrence of descending optic neuritis, unattended by symptoms of intracranial pressure. In young children premature closure of the fontanelles, with blindness, would point to meningitis; enlargement of the head, to tumor.

Hydrocephalus may also have choked disk, and is usually associated with depressed mental capacity. Slow enlargement of the head belongs either to this disease or to tumor, in young children. The rolling down of the eyes and subsequent retraction of the head point to an effusion. Ventricular effusions are not infrequent complications of tumor, especially of tubercular tumor; but the idiopathic disease does not occur except in very young children.

Multiple cerebro-spinal sclerosis may for a time simulate tumor, the disease being characterized by headache, vertigo, disturbances of speech and of vision (diplopia and amblyopia), and by the occurrence of apoplectiform attacks, followed by incomplete hemiplegia. The latter, however, are rare in tumor, but are apt to be frequently repeated in sclerosis. In sclerosis, on the other hand, there is an absence of convulsions and of motor paralyses, except after apoplectiform attacks. Instead, there is a diffused loss of power, with muscular rigidity, absence of vomiting and choked disk. Finally, the appearance of the characteristic tremor of the limbs is a positive symptom which decides the question in favor of sclerosis.

Locomotor Ataxy.—It may occasionally be difficult to distinguish the ataxia of cerebellar tumor from that of tabes spinalis. But in the tumor the patient has a staggering or reeling gait, like that of a drunken man, and there is no sign of ataxy in either upper or lower extremities when the patient is in a horizontal position (Althaus). The alterations of sensibility, characteristic of tabes, are absent in tumor, and most of the positive symptoms of tumor are absent in tabes.

Abscess of the brain, which, from its focal symptomatology, is ranked by Ball and Krishaber with tumors, sometimes simulates typhoid fever with pronounced cerebral symptoms. The absence of either pulmonary or abdominal symptoms, however, may prevent error, until the appearance of some localized paralysis decides the diagnosis. Two focal diseases of the brain often resemble tumor extremely—cerebral hæmorrhage and softening.

Cerebral Hæmorrhage.—The onset of the paralysis is sudden, instead of being slow and insidious, and the paralysis is usually at once complete. But the cranial nerves are rarely affected, with the exception of the facial; vomiting, headache, vertigo, and choked disk are absent, as are also mental symptoms after recovery from the apoplectiform shock. Hæmorrhage into the meninges, which scarcely ever occurs except in children and old people, does not resemble tumor in any of its symptoms with the exception of convulsions.

Softening.—The diagnosis from tumor is often extremely difficult when the softening is, from the beginning, chronic in character. Lesions of special senses are much less frequent in softening, and choked disk is rare; so also are lesions of cranial nerves, vomiting, and convulsions; while the headache is less circumscribed and intense. Contractures of paralyzed limbs are more frequent. Psychic alterations are marked, but are of a different character from those of tumor. There is emotional instability instead of irritability, dementia rather than the depression and apathy of tumor.

A diagnosis of the nature of the tumor can rarely be made.

Carcinoma is often indicated by the rapid progress of the symptoms, and by signs of multiple foci successively developing. Perforating tumors are almost invariably malignant—carcinoma, sarcoma, or osteo-sarcoma. The tumor is nearly always primary, and destroys life before it has occasioned cachexia.

Tubercular tumor often complicates tubercular meningitis, or is complicated by it. In either case the focal symptoms are much obscured by those of the diffuse disease. When isolated, a tubercular tumor may be suspected from the youth or scrofulous constitution of the patient.

Gummata.—Their diagnosis principally depends upon the presence of other signs of syphilis. The evolution is relatively rapid, and the invasion of drowsiness and coma may be hastened by the coexistence of diffused endarteritis.

Glioma.—This remains the most probable when the diathetic tumors have been excluded. It not infrequently develops after a blow on the head, and then seems to result from chronic inflammation of the neuroglia.

Intracranial aneurisms occasion symptoms which are indistinguishable from those of neoplasms proper. It is the basilar artery which is most often affected, and the symptoms then resemble those of tumors of the pons. But all the arteries are liable to be the seat of this lesion. It is said that headache is more diffuse and more intense than with other tumors, while vomiting is less frequent. Sudden attacks of loss of consciousness often occur, due undoubtedly to inequalities in the distention of the tumor, and consequent variations in the brain pressure.

Aneurisms of the posterior communicating artery occasion symptoms of motor-oculi paralysis (ptosis, external strabismus, fixed dilatation of the pupil), and finally, —the effect spreading to the corpora quadrigemina—amblyopia. When the aneurism is seated on the internal carotid, the sensitive root of the trigeminus may be affected; hence neuralgias or anæsthesia. Aneurisms of the carotid which communicate with the cavernous sinus are characterized by exophthalmia, and a susurrus which is heard when the stethoscope is applied over the eyeball (Case Gruening).

The termination of aneurismal tumors is peculiar, being always by rupture and sudden death, with the symptoms of intracranial hæmorrhage.

Abscesses of the brain comport themselves like an acute tumor. Their evolution is habitually much more rapid, and their progression much more regular than that of neoplasms. There is sometimes fever, but often this is absent, and the tumor may be entirely latent for some time. An abscess is always to be suspected when local-

ized cerebral symptoms develop in the course of an otitis media. Extremely chronic cases of this aural affection sometimes pass into an acute exacerbation, during which the cerebral membranes become infected through the roof of the tympanum, through the fenestræ, or through the auditory canal.

Prognosis.—The prognosis of cerebral tumor is not modified by the diagnosis of either the seat or the nature of the tumor, unless the latter can be shown to be syphilitic. Gummatous tumors sometimes yield with remarkable rapidity to the mixed treatment for syphilis. All others are invariably fatal, but after a longer or shorter lapse of time, and with somewhat different modes of termination. Thus, as has been said, aneurisms terminate by rupture, and death occurs with all the symptoms of cerebral hæmorrhage. In the majority of cases the patients die in coma, gradually developed from a condition of apathy and drowsiness. These states are associated with continually increasing brain-pressure, which often results in œdema. Sudden death is not uncommon, and is dependent upon inhibition of the cardiac centre. This sudden death may occur as an accident after the most variable duration of the disease; but even the mode of death which seems to indicate the natural evolution of the morbid process, leaves a most variable time for this to be accomplished. The patient sometimes dies as early as ten or even eight weeks from the appearance of the first symptoms; in other cases, these have been prolonged for ten years.

Pathological Anatomy.—The histological structure of many cerebral neoplasms, including aneurisms, does not differ from that of the same growths in any part of the body. Tubercular tumors, like miliary tubercle, always start from the lymphatic sheaths of the blood-vessels, beginning in a local accumulation of adenoid elements. Gliomata are a species of sarcomatous tumors, which are peculiar to the brain. They were described as neuromata, until Virchow demonstrated that they contained no nerve elements, but developed from the neuroglia. The glioma may consist almost exclusively of cells, and is then called a medullary glioma; or it may contain a large amount of connective-tissue, which either remains soft and of the myxoma type (myxoglioma), or becomes hard, fibrous, or even cartilaginous (fibrous glioma). Finally, some among these tumors are so rich in vessels as to have acquired the name telangiectasic gliomas. All develop from the neuroglia. The tumor appears as a grayish mass, becoming pink or red as vessels develop in it. If these are numerous, apoplexies may take place into the substance of the tumor. The three forms of malignant tumor of the brain are sarcomas, carcinomas, and melanoid tumors. The first are closely related to the gliomas, arising like the medullary variety of the latter; the chief difference consisting in the greater size of the cells and the larger amount of intercellular substance. Cancer of the brain is nearly always encephaloid, primary, and not infrequently congenital. The growth is rapid, and the size ultimately attained by the tumor is in inverse proportion to the vital importance of the part of the brain in which it is seated. Enucleation of the tumor is impossible. Cancer of the upper part of the cerebral hemispheres not infrequently perforates the dura mater, and even the skull. Conversely, cancer of the eyeball, usually melanotic, constantly tends to penetrate the brain.

Melanoid tumors are forms of carcinoma in which the tissue is infiltrated with pigment. Their most frequent seat is the eyeball, the pigment being derived from that of the choroid.

Hydatid cysts are found in the brain, but they usually remain latent, especially if small and multiple. Other forms of cyst are not infrequently formed by hæmorrhagic effusion, by softening of brain-tissue from extensive necrobiosis, or by the softening of myxomatous tumors.

Complicating Lesions. — With glioma, congestion and hæmorrhage in the vicinity of the tumor are the most frequent complications, the latter often being the cause of death. The tissue around the tumor is often the seat of an inflammatory softening. Effusion into the ventricles is often caused by compression of vessels which return blood from the choroid plexus. Such effusion is common with tubercle, and then may depend on granular thickening of the ependyma.

A zone of non-inflammatory softening surrounds most tumors. It depends upon necrobiosis of nerve-tissue, from localized obstruction to the circulation and œdema. When this softening is extensive, functional regions quite different from those actually occupied by the tumor become involved. This circumstance, as has often been shown, by complicating the symptoms, often materially obscures the diagnosis.

When the fibres of the pyramidal tract have been affected by the tumor, descending degeneration or secondary sclerosis may set in, and even reach the lateral columns of the cord. This is, however, much less common than after hæmorrhage; and, correlatively, late rigidity is correspondingly rare. Conversely, the appearance of rigidity in limbs paralyzed from the effects of a cerebral tumor, often indicates that hæmorrhage has been excited in its vicinity.

Treatment.—There is no radical medical treatment except for gummata, and for these the mixed treatment sometimes yields brilliant results.

The suggestion has recently been made to remove tumors situated near the surface of the brain by a surgical operation. The suggestion has been carried out in the following remarkable case (Bennett and Godlee, London *Lancet*, December 20, 1884):

Farmer, aged twenty-five. Symptoms lasted three years, beginning one year after a blow on the head. Paroxysmal twitching of the left side of the face and tongue. General convulsions, then local spasms of the left arm, cessation of the convulsions, paresis of the arm, twitching of the left leg, violent headaches, attacks of vomiting, double optic neuritis. Patient trepanned at point of skull corresponding to upper (?) part of the fissure of Rolando. Dura divided, ascending frontal convolution exposed, and found to be distended. Incision of one-fourth inch disclosed hard glioma, of the size of a walnut. Patient at once relieved of lancinating pains, vomiting, and convulsions, but paresis of left leg increased. Improvement up to twenty-first day. Then rigor, fever, nausea, and pain in head; hernia cerebri. Death on twenty-eighth day. On post-mortem examination, signs of meningitis at lower portion of the wound, spreading downward toward the base of the brain on the same side, the whole of which was inflamed and covered with plastic lymph. *Mary Putnam-Jacobi.*

[1] Dictionnaire Encyclopédique, art. Cerveau.
[2] Boston Med. and Surg. Jour., 1882. [3] Brain, January, 1879.
[4] Samt.: Arch. f. Psych., v., 1874.
[5] Bramwell: Edinb. Journal, 1878, vol. xxvii., p. 1.

BRANCHIAL CYSTS. Branchial cysts are cystic tumors of the neck and some parts of the head, originating from congenital defects of development, their matrix being composed of fœtal epiblastic or hypoblastic tissue which remains in its embryonal state for an indefinite time, and later, by proliferation of its epithelial elements, gives rise to a distinct and characteristic type of cystic tumors. They have been variously designated as branchial cysts (Roser), dermoid cysts of the sheath of the internal jugular vein (Langenbeck), deep-seated atheromatous tumors (Schede), tumors of the branchial clefts (Virchow), hydrocele colli congenita (Maunoir), hygroma colli (Luschka), and atheromatous cysts of the lymphatic glands (Luecke), in accordance with the nature of the contents of the tumor or the peculiar etiological views entertained by the different authors. It appears to me, however, that "branchial cysts" is the most appropriate term, as it expresses at once both the location and character of the tumor.

Toward the end of the first month of fœtal life we see, under the frontal process, open in front and bounded on the sides by four plates, the pharyngeal cavity. The upper pair of plates constitute the first branchial arch. The next three pairs of plates make up the second, third, and fourth branchial arches, which decrease in size from above downward, so that their median interspaces in front are

narrow above and wider lower down. Between any two individual branchial arches, on each side, remains a transverse cleft, and, during early fœtal life, these branchial clefts, with the exception of the first one, from which the external auditory canal, the cavity of the tympanum, and the Eustachian tube are developed, unite. The neck is thus built up of continuous lateral walls. From the second branchial arch are developed the styloid process, the stylohyoid ligament, and the lesser cornua of the hyoid bone; the third arch forms the large horns and the body of this bone; the fourth arch assists in forming the soft tissues of the neck. The larynx, trachea, and adjacent glands are developed from other centres of fœtal growth. The primary origin of these tumors necessarily must correspond to the location of one of these branchial clefts, and clinical experience has demonstrated that they are most frequently found in the region of the second and third branchial clefts, in the vicinity of the larynx and pharynx, and in intimate relation with the sheath of the large vessels of the neck, in contradistinction to dermoid cysts about the orbits and in the scalp, which are more superficially located. In the case of a young lady, Langenbeck observed a cyst situated on the left side of the epiglottis and pharynx, which occupied one-half of the floor of the mouth, and which projected from underneath the chin on that side in the shape of a smooth tumor of the size of a fist. Respiration, deglutition, and the motions of the tongue were greatly impeded. The cyst contained eight ounces of atheromatous matter. The same author states that he has frequently found these tumors attached to the greater horn of the hyoid bone or to the thyro-hyoid ligaments, localities which plainly indicate that they originated from remnants of former branchial clefts.

As they are often in intimate connection with the sheath of the large vessels of the neck, it is very important to study their anatomical relations to these important structures. The jugular vein is surrounded, throughout its whole course in the neck, by a distinct and separate sheath of areolar tissue which, on the outer side of the artery, penetrates into the deep tissues of the neck, thus completely separating the two vessels. The jugular, enclosed in its sheath, may be easily drawn over the artery toward the median line without producing any change of location of the artery. The vein being in front of the artery and covering half of the lumen of the latter, it can be readily understood that when the vein is drawn forward, with its sheath, it can be injured, while the artery is not exposed to the same danger. Branchial cysts of the second and third clefts are always observed in the sheath of the large cervical vessels, usually in the carotid triangle above the omo-hyoid muscle. They appear to occur more frequently on the left side of the neck. Their shape is invariably round or oval, with a smooth surface. The contents of these cysts being either fluid or semifluid, fluctuation can be felt, more particularly if the tumor is palpated between two fingers, one of which is placed in the pharynx or on the floor of the mouth, and the other on the external surface. Only lateral motion of the tumor is possible, on account of its peculiar attachments to the deep tissues of the neck. If the tumor is only of moderate size the pulsations of the carotid artery can be felt on its inner margin. If it is large it overlaps the artery, in which case the pulsations of the vessel are communicated to the tumor. Smaller tumors can be made to pulsate by bending the head backward and in a direction opposite to the tumor.

Branchial cysts should be classified according to their contents. The cyst-walls being lined with epithelium, the only histological elements in the contents are epithelia. In most instances the epithelia lining the cyst belong to the tessellated variety, but Rehn discovered, in a blind congenital fistula ending near the mucous membrane of the pharynx, ciliated epithelium; and Neumann found cylindrical and pavement epithelium in two cystic tumors of the neck, one of which was congenital while the other was developed in later years. The physical and chemical properties of the cyst contents will depend largely on the amount and degree of activity of the retrograde processes which may have taken place in the epithelium.

Clinical experience and pathological examination have shown that these tumors, according to the physical properties of their contents, may be divided into the following four principal varieties:

1, Mucous cysts; 2, atheromatous cysts; 3, serous cysts; 4, hæmato-cysts.

Variable as the contents of these varieties may be, more uniformity is observed in the structure of the cyst-wall. In the primary stage of the affection it consists of a connective-tissue capsule with an epithelial lining on its inner surface, and a delicate layer of a loosely connected reticulum of connective-tissue (pericystium) which is very vascular, and covers the outer surface of the cyst. A high degree of intracystic pressure may cause atrophy of the epithelial lining and thinning of the walls of the sac, and, on the other hand, inflammatory proliferation produces great thickening of the cyst-walls. While dermoid cysts contain the characteristic secretions of the skin and its appendages, the branchial cysts only contain the products of the epithelial cells, because their walls do not contain any hair-follicles, sebaceous or sweat-glands, as the branchial clefts close before these appendages are formed.

I. Mucous Branchial Cysts.—As a primary formation, this form of branchial cyst is usually found in the upper branchial clefts. Their origin is attributable to an imperfect closure of the upper portion of the branchial tract; consequently the cyst-wall may derive its lining from the mucous membrane of the pharynx, and the retention of the physiological secretion produces a mucous cyst. Many of the so-called ranular cysts, about the base of the tongue, belong to this variety of tumors.

2. Atheromatous Branchial Cysts.—This form of branchial cysts has been described by some authors as deep-seated atheromatous cysts of the neck (Schede), and dermoid cysts of the sheath of the large vessels of the neck (Langenbeck). They are usually located in the second and third branchial tracts in the region of the hyoid bone, and are intimately connected with the sheath of the large cervical vessels. These cysts contain an atheromatous material resembling the contents of an ordinary retention cyst of the skin, with this difference, however, that they never contain anything which would indicate the presence of hair-follicles, as lanuginose hair or sebaceous material, or any of the more complicated products of dermoid cysts. For the purpose of furnishing a clear clinical picture of this form of branchial cysts, I will give a synopsis of two cases which have come under my observation.

Case I.—Mrs. H——, aged thirty-six. German. Family history reveals no tendency to congenital malformations. About one year ago the patient discovered a small tumor on the right side of the neck, between the angle of the jaw and the larynx, which slowly increased in size, and, after a few months, became the seat of an acute inflammation which terminated in suppuration, requiring an incision for the relief of urgent symptoms. The fluid which escaped consisted of pus mixed with a gruelly substance. Prompt relief followed the incision. The inflammatory symptoms subsided and the tumor diminished in size. In a few weeks the opening closed, leaving a small and painless swelling. The same symptoms were repeated about four months subsequently. When the patient came under my observation, during the summer of 1883, I found a tumor about the size of a hen's-egg, located between the angle of the jaw and the larynx, resting directly upon the large vessels of the neck, as was evident from the distinct pulsations which it received and which could be seen and felt. The posterior portion was under the sterno-cleido-mastoid. Over its centre was seen the scar which had resulted from the previous incisions. The swelling presented a regular, smooth surface and an oval outline, with the long diameter parallel to the cervical vessels. It was only slightly movable from side to side, and perfectly immovable from above downward, showing that it had a firm point of attachment to the deep tissues of the neck. Fluctuation could be detected on the outer surface and also through the mouth. The original location corresponded to the third branchial cleft. As it had on two different occasions undergone acute inflammatory changes without any benefit resulting from them, the extirpation of the cyst

was deemed the only measure which promised a permanent result. The operation was done under antiseptic precautions. A straight incision was made over the tumor, parallel to the sterno-cleido-mastoid. The cyst was firmly adherent to the surrounding tissue, as the result of antecedent inflammatory infiltrations, and required much time and patience to effect its separation. After it had been isolated from all attachments on its sides, it was seized with a tenaculum-forceps and drawn forward and toward the median line of the neck, while the sterno-cleido-mastoid was held in an opposite direction, so as to afford easy access to its base. The attachments here were very firm, and it appeared as though the base of the tumor and the large cervical vessels underneath were embedded in a mass of cicatricial tissue. Keeping as close to the cyst-wall as possible, I carried out the dissection very carefully, proceeding mostly with blunt instruments. When nearly one-half of the pedicle had been separated in this manner, we were suddenly surprised by a tremendous gush of dark venous blood, which in a second flooded the whole field of operation. It was only too evident that the internal jugular vein had been torn, and, for the purpose of preventing further loss of blood, and to guard against instant death by admission of air into the vein, I made firm digital compression above and below the injured vein, while my assistant pushed a sponge into the wound. Hæmorrhage was controlled in this manner, and, as soon as I could be relieved by an assistant, I carefully removed the sponge, and, after locating as nearly as possible the exact seat of bleeding, I seized the vein, with some of its adjacent tissues, with a stout pair of hæmostatic forceps. I was fortunate enough to grasp the bleeding point at the first attempt, and the hæmorrhage was completely controlled. The tumor was now removed, and by making slight traction on the forceps I drew the vein forward and applied a catgut ligature without isolating the vessel. I was unable to ascertain the exact size or direction of the wound in the vein, but the ligature arrested the hæmorrhage promptly and permanently. The wound was thoroughly irrigated, and, as in Langenbeck's case, the vein seemed to disappear underneath the deep tissues of the neck. In the wound could be seen the œsophagus, lateral wall of the larynx, carotid artery in its sheath, and the great horn of the hyoid bone. After suturing and draining the wound I applied a graduated compress. For the first twenty-four hours after the operation the patient suffered from intense headache on the corresponding side, which induced me to believe that the circulation in the vein had been completely interrupted, either by the ligature alone or by the formation of a thrombus at the point of ligation. After the first twenty-four hours the patient suffered no further inconvenience. The wound healed by primary union, and the recovery has been permanent and complete. There is no question but that the adhesions of the cyst with the sheath of the cervical vessels were due to the attacks of acute inflammation which had preceded the operation on two different occasions. A microscopical examination of the contents showed flat epithelial cells, cholesterine crystals, fat granules, and a mass of débris, the product of epithelial degeneration. The cyst-wall was composed of connective-tissue, thickened and infiltrated with embryonal elements, and lined with epithelial cells.

The next case very nicely illustrates the oral variety of branchial cysts.

Case II. — Mary H——, aged twenty-five. German. Her family history is good, especially as regards congenital malformations, such as tumors or fistulæ in the cervical region. Patient has always appeared round and full underneath the chin, but during the last four years a tumor has been growing rapidly on the floor of the mouth, until, at present, it is considerably larger than a goose's egg. The mouth is completely filled by it, the tongue is pressed against the palate, its movements are limited, only the tip of it being visible at the upper border of the tumor, and speech and deglutition are greatly impeded. Laterally the tumor extends very near the angles of the inferior maxillary bone, and downward it overlaps the larynx and upper part of the trachea, entirely obliterating the round contour of the upper cervical region. It is painless and distinctly fluctuating to the touch, presents a smooth surface, and gives rise to no inconvenience except that which results from its mechanical interference with speech and deglutition. When the patient opens her mouth, the apertures of Wharton's ducts are plainly visible on each side of the median line, and, by exerting lateral pressure upon the submaxillary glands, the patient can expel a stream of saliva from them. Previous treatment, consisting of external applications of iodine, etc., had had no effect on the growth. Desiring to avoid any deformity resulting from an external cicatrix, I decided to remove the tumor through the mouth. A linear incision was, therefore, made in the median line, extending from above downward from the tip of the tongue to the symphysis menti, the ducts of the salivary glands being carefully avoided. Adhesions existing between the tumor and its surrounding tissues were easily severed, when it was seen that it would be impossible to remove the tumor in its entirety, owing to its immense size. The sac was, therefore, opened, and a large quantity of its gruelly contents removed by pressure. The operation was then continued, without any difficulty, until the entire cyst had been removed. It was now noticed that the cyst was constricted, in its middle, by the inferior maxillary bone, the upper and lower portions of it bulging out on both sides of the constriction. There was no hæmorrhage worth mentioning. The body and great wings of the hyoid bone could be plainly felt in the posterior recess of the wound. The cyst-wall was thin, and its external surface was quite vascular. The microscopical examination of the contents of the cyst, as well as the primary location of the tumor, revealed its branchial origin. The wound healed very kindly, and shortly afterward nothing in the looks of the young lady showed any traces of the deformity which had previously disfigured her face and neck.

3. Serous Branchial Cysts.—This variety of branchial cysts is composed of thin cyst-walls and serous contents, and may develop from any one of the branchial clefts failing to undergo complete obliteration. This affection has been described under the name of *hydrocele colli* (Maunoir), congenital hygroma of the neck (Wernher), congenital hydrocele of the neck, and congenital cystic tumor of the neck (Thomas Smith). Maunoir, under the name of *hydrocele colli*, described certain serous cysts occurring between the angle of the jaw and the mastoid process, and between the larynx and the anterior margin of the sterno-cleido-mastoid, a region which corresponds to the second and third branchial clefts, which were supposed not to have been obliterated at the time of birth. We have seen, however, that branchial cysts are not necessarily developed during intrauterine life or soon after birth. All that is necessary is that the matrix for the cysts be present at birth, from which, at some future time, the tumor may be developed. These tumors appear as single or multilocular cysts with thin membranous walls; their internal surface is lined with pavement epithelium. Like cavities lined with a serous membrane, they contain a limpid, watery, or tenacious fluid, holding in suspension epithelial cells and cholesterine crystals. These cysts are formed anywhere in the neck, within the area of the branchial clefts, between the lower jaw and the clavicle. They are usually deep-seated, though occasionally they are superficial. They are painless, and give annoyance only from their size. Clinically they may be recognized from their location, their globular cystic form, soft fluctuating feel, and painless growth. The existence of tessellated epithelium upon the inner surface of these cysts has been demonstrated by Neumann and Baumgarten. When these cysts spring from the second or third branchial clefts they are usually deeply located. Hueter, in extirpating a tumor of this kind in a child two years of age, ascertained that it extended between the two carotid arteries back to the walls of the pharynx. When they are deeply situated they are usually in contact and connected with the sheath of the large cervical vessels, and receive a distinct impulse from the underlying artery. When thus located, they offer the same difficulties to ex-

tirpation as do those of the atheromatous variety. The following case may serve as an illustration of this type of branchial cysts:

The patient was a healthy, strong, male child, six months of age. No history of congenital malformation, especially branchial fistula, in the family. When the child was born, a small tumor, the size of a pea, was discovered on a level with, and somewhat to the inner side of, the sternal origin of the sterno-cleido-mastoid muscle. The tumor was painless and movable, but rapidly increased in size. When the child was brought to me, the tumor was as large as a walnut. The skin over it was natural in appearance and movable. The tumor itself presented a smooth surface. Fluctuation was distinct, but the cyst appeared to be somewhat firmly attached to the adjacent tissues. The cyst was readily enucleated, the adhesions not being very firm except over the most prominent point of the tumor, where inversion of the skin had undoubtedly occurred during the closure of the external opening of the fourth branchial tract. The adherent portion of the skin was excised with the tumor. The cyst was found to be oval in shape, and smooth, and the outer layers were quite vascular. The walls being thin and the contents serous, the whole tumor presented a translucent appearance. The wound was closed with sutures, and healed by primary union under an antiseptic dressing. Similar cases have been reported by Smith, Vonwiller, Frederick Treves, and others.

Thomas Smith reports a case which would show that these cysts may occasionally disappear by spontaneous absorption of their contents. The patient was a healthy babe, three weeks old. Immediately after birth a swelling was noticed in the neck, which rapidly increased in size. When the patient was first seen, a cystic tumor occupied almost the entire region of the left side of the neck, extending from under the lower jaw to the clavicle. The mother objected to any kind of treatment. Three months later the child was seen again, when the growth had greatly diminished in size. There was nothing to be felt but a loose, flabby, cystic mass, not much larger than a hen's egg. The skin over it was shrivelled, loose, and baggy. Three months later the tumor was still smaller.

4. Hæmato-cysts of Branchial Clefts.—In some instances of serous branchial cysts the fluid is discolored by an admixture of blood from minute hæmorrhages into the sac, but when the contents are of such dark color as to resemble venous blood, they are properly called hæmato-cysts, and, from a pathological, diagnostic, and clinical point of view, they constitute a distinct and well-marked variety of branchial cysts. Albert remarks that two kinds of these cysts have been observed: 1. Such as may be emptied by pressure, and are in communication with blood-vessels. 2. Those which cannot thus be emptied by pressure, and which simulate the appearance of an ordinary serous cyst so closely that their nature is only recognized by puncture. The latter class, when they occur in the neck, usually belong to the branchial cysts, because they are observed during early life, and originate in places which correspond to the location of the branchial clefts. This variety of cysts has been called *hæmatocele colli* by Michaux, and *hæmatoma* by J. P. Frank. Hæmato-cysts resemble the serous cysts in every particular, with the exception of the presence of blood in their contents. It is not an easy matter, however, to make a diagnosis of this variety of branchial cysts, and it should always be made by exclusion, due attention being given to the location of the cyst, the time of development, and the character of its contents.

Branchial cysts are of comparatively rare occurrence, and the statistics cannot be relied upon in estimating the frequency with which these tumors occur, as many of them have been classified and described under the generic and indefinite term, "cystic tumors of the neck," without regard to their etiology. Guret, in 1855, compiled 44 cases of serous and 6 cases of atheromatous cysts. Since that time quite a number of new cases have been described by Volkmann, Billroth, Esmarch, Roser, Langenbeck, Luecke, and Bruns. The serous variety of cysts is more likely to develop early; they are often congenital, or appear during infancy or childhood, while the atheromatous cysts are the products of early adult life. Of 53 cases mentioned by Schede, 9 occurred between the 1st and 10th years of life, 21 between the 11th and 20th, 10 between the 21st and 30th, 6 between the 31st and 40th, 5 between the 41st and 50th, and 2 between the 51st and 60th.

Like the dermoid cysts, the branchial tumors show a tendency to develop during the period of puberty, at a time when the epiblast enters upon a new phase of development and becomes the seat of renewed and active tissue-proliferation. The remnants of the branchial cleft may remain dormant, as a matrix for the future growth of the tumor, for an indefinite time, and may become the seat of tissue-growth during puberty, or upon the advent of any determining cause or causes. There are many instances in which remnants of fœtal tissue have remained latent in the branchial tracts throughout a lifetime, for want of an exciting cause of sufficient strength to call into morbid activity the slumbering forces inherent in the histological elements of the matrix.

Diagnosis.—The diagnosis is oftentimes no easy task. The importance of the tissues and organs which are in close and intimate relation with these tumors renders it imperative upon the surgeon to make a correct diagnosis before an operation is undertaken for their removal. The following conditions may simulate a branchial cyst: 1, Aneurism; 2, angioma; 3, dermoid cysts; 4, retention-cysts; 5, affections of lymphatic vessels and glands; 6, struma cystica; 7, simple serous cysts.

1. *Aneurism.*—As most of the branchial cysts are in immediate contact with the large cervical vessels, and usually receive the impulse from the underlying artery, it is always important to exclude the possible presence of an aneurism. At the age when branchial cysts are most frequent, aneurisms, except of traumatic origin, are exceedingly rare. Pressure does not affect the volume of a branchial cyst, and the pulsations are only felt in one direction, away from the artery. Auscultation furnishes another important negative symptom. An exploratory puncture, which should always be made in doubtful cases, will also furnish valuable information, as it will afford an opportunity to examine the contents of the tumor. In hæmato-cysts the contents may resemble venous blood, but a microscopical examination will show, in addition, the presence of epithelium or the products of epithelial degeneration.

2. *Angioma.*—Deep-seated angiomata are occasionally met with in children, and, as the skin may present a perfectly natural appearance, they might be mistaken for branchial cysts. If the tumor disappears under pressure it may be an angioma, but never a branchial cyst.

3. *Dermoid Cyst.*—As dermoid cysts may occur in the same localities and at the same age, they are frequently mistaken for branchial cysts, and *vice versa*. As both varieties of cysts require the same treatment, a positive diagnosis is not essential. A correct anatomical diagnosis can be made by examining the contents and the cyst-walls. A branchial cyst contains only one constant histological element—epithelium—as obliteration of the branchial tracts takes place long before the appendages of the skin are formed. A dermoid cyst, on the other hand, contains the products of secretion of the skin and its appendages. The walls of a branchial cyst are composed of a connective-tissue capsule, lined with epithelium, while the sac of a dermoid cyst is composed of true skin.

4. *Retention-Cysts.*—The only two forms of retention-cysts which call for consideration in this connection are the true atheroma of the skin, the result of obstruction in the ducts of the sebaceous glands, and the retro-tracheal cyst, which originates in a similar manner in the retro-tracheal glands. Cysts arising from the second and third branchial clefts are always deeply located, and when first observed are distant from the skin, while an atheroma primarily develops in the skin, and usually grows in a peripheral direction. Lanuginose hair is sometimes found in the contents of an atheroma, the product of retained hair-follicles; it is never seen in branchial cysts.

Virchow has called attention to a peculiar kind of re-

tention-cyst which is found between the œsophagus and the trachea, and which arises from an obstruction in the duct of one of the retro-tracheal glands. These glands are situated between the trachea and œsophagus, but their ducts traverse the entire thickness of the tracheal wall and terminate upon the free surface of the mucous membrane. These cysts are so located that they give rise to distressing symptoms, referable to deglutition and respiration, before they attain any considerable size, differing greatly in this respect from the clinical history of a branchial cyst.

5. *Affections of Lymphatic Glands and Vessels.*—A deep-seated, isolated, caseous, lymphatic gland might be easily mistaken for a branchial cyst, more particularly after the cyst had become the seat of inflammatory infiltration. It is seldom that we meet any such extensive pathological changes in a single lymphatic gland as to simulate a branchial cyst, without participation of one or more adjacent glands. Again, in cases of disease of the lymphatics, the general condition of the patient usually indicates the existence of a serious affection, while a branchial cyst is a purely local condition, never affecting the general health except when it interferes with important functions of the neighboring organs. Cancerous or sarcomatous affections of the lymphatic glands would reveal themselves by the clinical symptoms characteristic of these tumors.

6. *Struma Cystica.*—Cystic degeneration of the thyroid gland proper can never be mistaken for a branchial cyst, as the connection of such cysts with the thyroid body can be traced without any difficulty; but recently it has been ascertained that not infrequently small accessory thyroid glands exist in the neck, which may undergo cystic degeneration, and Madelung has made the assertion that the so-called hydrocele of the neck is only a struma cystica of a supernumerary thyroid gland. The possibility of a cystic degeneration of such an accessory thyroid body should always be borne in mind in examinations for branchial cysts.

7. *Simple Serous Cysts.*—Virchow asserts that many of the serous cysts develop without a particular matrix, as new formations, in the connective-tissue. It is a well-known physiological fact that the connective-tissue cells are occasionally converted into endothelia, as during the formation of new synovial membranes; hence we should *à priori* expect that in simple serous cysts, developed from connective-tissue, the inner surface of the sac would be lined with endothelia, the existence of which would be sufficient to disprove their branchial origin.

In repetition I will enumerate the following points, which should be considered in the differential diagnosis of cystic tumors of the neck with special reference to branchial cysts: 1. Primary seat of tumor; 2, effect of pressure; 3, general condition and age of patient; 4, character of contents.

Prognosis.—Branchial cysts always remain purely local affections and manifest no tendency to destroy life, except when they are of sufficient size to interfere, by their pressure, with the performance of important functions of neighboring organs. On the other hand, it may be said that they manifest no tendency to spontaneous cure, and prove exceedingly obstinate to all forms of treatment short of complete extirpation.

Treatment.—The inner surface of branchial cysts being lined with epithelium, it is evident that obliteration of the sac can only be obtained after the destruction or removal of this epidermal lining. The radical treatment for the removal of these tumors must have for its object either the production of an artificial inflammation, in the interior of the sac, of sufficient intensity to destroy the epidermal matrix, or complete extirpation of the cyst. The former procedure is exceedingly unreliable, and extirpation in many instances must be looked upon as a very formidable and dangerous operation. The following means have been employed in the treatment of branchial cysts: 1, incision; 2, actual cautery; 3, seton; 4, puncture, with subsequent injection; 5, extirpation; 6, antiseptic drainage.

1. *Incision.*—In all cases in which incision was practised, the relief from existing symptoms was prompt; the cyst collapsed, a certain amount of inflammation was established, suppuration followed, and, in some instances, the patient and surgeon were led to believe that a radical cure was obtained. Usually, after healing of the wound, a small nodule remained, which, in a few months, again became the seat of active tissue growth, and a speedy relapse was an almost constant occurrence. In infants the laying open of cysts is a perilous plan of treatment. Volkers relates a case in which a cystic tumor was laid open in a new-born child, who died sixteen days afterward in consequence of the operation. A branchial cyst cured by simple incision is reported by Billroth. In the case of serous cysts, in which the seton and iodine injections have occasionally been successful in producing obliteration, it seems to me that the same object would be accomplished more speedily and safely by incision and drainage practised in a similar manner as in Volkmann's operation for hydrocele.

2. *Actual Cautery.*—Dieffenbach employed the actual cautery in opening the cyst in one of his cases, after he had made an unsuccessful attempt at removing it by extirpation, and after incision had failed in producing obliteration of the sac. The use of the cautery met with no more encouraging result. It would seem to me that incision, combined with an energetic use of the cautery, would be most applicable in the most dangerous and formidable class of cases, viz., cysts which have become firmly adherent to the sheath of the cervical vessels by repeated attacks of inflammation.

3. *Seton.*—This form of treatment proved successful in several of Thomas Smith's cases of serous cysts of the neck, but in some of them their branchial origin does not appear to be established. Smith uses a single thread of silk, and removes it before suppuration sets in. If the tumor is polycystic, he attacks only one cyst at a time. Gurlt very justly has entered his protest against the use of the seton. As in the case of hydrocele, the seton is an exceedingly uncertain agent in calculating with precision the amount of inflammatory action which will follow its use. The degree of irritation produced by it is very liable to be inadequate to produce adhesion, or it exceeds the desirable boundary, and induces suppuration with all its evil consequences. Butlin reports the case of a young child, in whom a seton was passed through a serous tumor, and which was followed by death on the third day from the violence of the inflammation. For this and other obvious reasons, the seton should never be used in the treatment of branchial cysts.

4. *Puncture, with Subsequent Injection.*—In the transactions of the Fourth Congress of German Surgeons, the treatment of branchial cysts by puncture and injection was fully discussed. Esmarch's experience appeared to be the most extensive, and his results were more uniformly favorable than the practice of any other surgeon. He claims to have cured about a dozen cases by puncture and subsequent injection of Lugol's solution of iodine (Iodinii, pot. iod., āā 1.25; aquæ, 30.0). Whenever complete obliteration does not follow the first puncture, he repeats the operation. This method of procedure is as follows: By means of a fine hydrocele trocar the sac is emptied of its contents, when repeated injections of a one per cent. solution of carbolic acid are made, to remove the masses of epithelium adherent to the cyst-wall. These injections are continued until the water returns perfectly clear, then Esmarch injects from ten to twenty grammes of Lugol's solution of iodine, which, after gentle pressure to bring it in contact with the inner surface of the sac, is allowed to escape. The patient is then directed to return in six or eight weeks. Like a hydrocele, the cyst refills rapidly, and becomes somewhat painful. If, after the lapse of the time mentioned, the tumor has not greatly decreased in size, the same operation is repeated, and in about six months the cyst will be found atrophied to a small tubercle. According to Esmarch, the cure, in most cases, has been permanent. From the discussion which followed Esmarch's remarks, it is evident that the majority of German surgeons have no confidence in the efficacy of iodine injections in obliterating branchial cysts. If we consider the numerous failures of iodine injections in

cases of hydrocele, in which the anatomical conditions for success are so much more favorable, we shall be better prepared to appreciate the causes of its still more frequent failures when used in the treatment of branchial cysts. In infants, even simple tapping is not always devoid of danger, as one instance of death is recorded, caused by puncture. The case occurred to Volkers, who tapped a cystic cervical tumor in an infant eight days old, the child dying of trismus on the third day.

5. *Extirpation.*—A positive diagnosis made, the best plan to pursue is to make an incision over the most prominent portion of the tumor, and, in case the adhesions can be separated without endangering the deep cervical vessels, the entire cyst should be removed. If inflammatory infiltrations obscure the field of operation at the base of the tumor, and after careful examination it is not deemed advisable to perform complete extirpation, the sac should be opened and the lateral walls excised; then the epidermal matrix which remains adherent to the sheath of the cervical vessels can be destroyed completely by a careful but vigorous use of the actual cautery. If an early diagnosis is made, and prompt treatment instituted, complete extirpation should always be attempted, and will, in the majority of cases, prove successful and comparatively free from danger.

6. *Antiseptic Drainage.*—In the case of infants and very young children suffering from large serous cysts, it would be imprudent to resort to any of the severer measures with a view to a radical cure. In such instances, drainage under antiseptic precautions should be resorted to as a temporary measure, and in some instances it may be followed by permanent results. The same course of treatment should be adopted in adults suffering from cysts which are inaccessible to any other operation, and in which irritating injections are contraindicated.

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N. Senn.

BREAD, CRUMB OF (*Mica Panis*, Br. Ph.). "The soft part of bread made with wheat flour." This is retained in the British Pharmacopœia as part of the basis of its Charcoal Poultice (*Cataplasma Carbonis*, Br.), added probably to the linseed meal, which the poultice also contains, to make it lighter and more porous. Bread is very frequently used in this country as the foundation of domestic poultices, and answers a good purpose where flaxseed is not to be had; but it is less plastic and more friable than the latter, and is apt to sour quicker. As a pill-mass it is entirely obsolete. *W. P. Bolles.*

BREAST, FEMALE. The structure of the female breast varies with its physiological requirements. During *lactation* and the latter part of *pregnancy* it reaches its maximum of development. The following description is based on that stage: The breast is a compound acinous gland without distinct septa, the various lobes being separated by loose connective and adipose tissue. The number of lobes corresponds with that of the efferent canals (sixteen to twenty). The lobes consist of a varying number of lobules, *i.e.*, small clusters of terminal vesicles (acini), in which the milk is secreted. The vesicles, round or pear-shaped in form, terminate in small tubes, these in ducts of larger calibre, which unite in the lactiferous (efferent) canals. Thus the individual lobes represent a system of ramifying ducts and their vesicles (see Fig. 522). The lactiferous canals converge toward

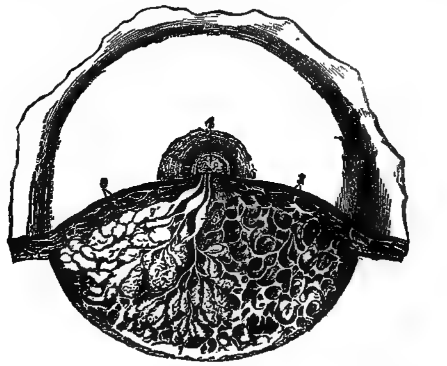

FIG. 522.—Dissection of the Lower Half of the Female Mamma during the Period of Lactation. (Luschka.) *a a a*, Undissected part of the mamma; 1, the mammilla; 2, areola; 3, subcutaneous masses of fat; 5, three lactiferous ducts passing toward the mammilla where they open; 6, one of the sinuses or ampullæ; 7, some of the glandular lobules which have been unravelled; 7′, others massed together. (Quain.)

the nipple, in which they assume a parallel course, and open in groups of two or three in the wrinkles of that organ by very small orifices. Beneath the areola they form dilatations (ampullæ, sinus lactiferi), serving as milk reservoirs. The walls of the efferent canals consist of fibrillated connective-tissue; those of the smaller tubes and vesicles are hyaline. In the nipple the canals are lined with stratified flat epithelium, the smaller ducts and the tubes with a single layer of low columnar, the terminal vesicles with cuboidal epithelium (Figs. 523 and 524). The whole canal system is accompanied by elastic fibres, fibrillated connective-tissue, and bands of smooth muscle fibres. The protoplasm and nuclei of the epithelium lining the terminal vesicles contain fat globules.

FIG. 523.—Mammary Gland of the Dog. Transverse section of a terminal vesicle, showing an early stage of the formation of fat globules. (Heidenhain.)

Shortly before and after delivery the vesicles and ducts are filled with a fluid abounding in colustrum corpuscles, large, round cells having indistinct nuclei and containing many fat granules. They are (probably) cast-off epithelial cells in a state of fatty degeneration derived from the terminal vesicles. The *nipple* is conical or cylindrical in form, and erectile, owing to circular and longitudinal bands of smooth muscular fibres. Its apex is provided with tactile corpuscles; its integument contains minute sebaceous glands. The *areola* surrounds the base of the nipple; it is of a rosy hue in the virgin, darker colored in pregnancy, owing to pigment (brown or yellow) deposited in the cells of the rete mucosum. Its papillæ are prominent, the sweat-glands voluminous. Highly developed sebaceous glands, the *glandulæ aberrantes* of Montgomery, discharge their contents partly on the free

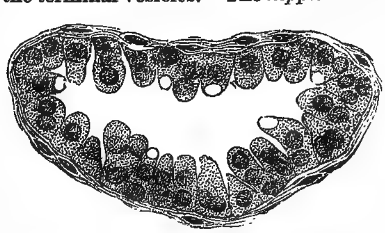

FIG. 524.—The same Anatomical Relations as are shown in Fig. 523. The gland, however, is in its highest stage of functional activity. (Heidenhain.)

surface, partly into the subjacent lactiferous canals. The *arteries* are derived from the superior thoracic, acromial thoracic, thoracica longa, the rami infracostales of the posterior or intercostal arteries, and the perforating branches of the internal mammary. The *veins* describe a radiating course in the areola (*circulus venosus Halleri*), transmit the blood to the circumference, and end in the cephalic, axillary, and internal mammary veins. Numerous plexuses of *lymphatic vessels* accompany the ducts and surround the acini. *Nerves* are numerous in the nipple and areola, and scanty in the interior of the gland. They are distributed principally to the blood-vessels, and are derived from the supraclavicular, the second, third, and sixth intercostal nerves. The breast is formed in the third month of *embryonic life*, and originally represents a group of enormously developed sebaceous glands. Up to *puberty* their development is the same in the two sexes. At this period the ducts in the female begin to ramify and form clusters of vesicles whose number is increased during pregnancy. In the male the ducts remain stationary at puberty, and atrophy in middle age. In the *virgin* the connective-tissue of the breast consists of dense and interlacing fibres forming a compact mass; adipose tissue between the lobes is wanting. The hyaline walls of the terminal vesicles are very thick, the epithelia cylindrical. After each childbed there is a subinvolution of the gland, the terminal vesicles diminishing in size, and the lumen of the ducts narrowing. With the *climacteric period* a permanent involution of the organ takes place, the terminal vesicles disappear entirely, and the ducts only remain in a collapsed state.

PHYSIOLOGY OF THE BREAST.—The breast is emptied of its contents partly by suction, partly by contraction of its smooth muscle fibres. The contraction is due to a reflex action of the motor nerves produced by the irritation of the sensory nerves of the nipple. During suction the gland is stimulated to increased secretion. Whether the amount of milk depends on blood-pressure and the action of the vaso-motor nerves alone, or whether there are secretory nerves proper, as in the salivary glands, is an open question. The influence of the emotions on quantity and quality of the milk is well known. The physiological experiment shows, that on irritating the mammary nerve (in the bitch) erection of the nipple, dilatation of the vessels, and secretion of milk ensue. Section of the cerebro-spinal nerves (in the goat) abolishes the erectility of the nipple, but does not interfere with secretion. It is a question whether the fat globules of the milk are secreted by the epithelia of the acini, the protoplasm of the cells merely expelling them by contraction; or whether they are derived from immigrated leucocytes changed and disintegrated into fat granules; or whether they owe their existence to the fatty degeneration and destruction of the cells of the acini, newly formed epithelial cells continually replacing the destroyed ones. The last-mentioned view seems to be most generally accepted.

The exact knowledge of the anatomy of the breast we owe to Langer. To Eckhard, Heidenhain, Laffont, Partsch, Roehrig, Stricker, and others is due the credit for successful physiological investigations.

L. Bremer.

BREAST, FEMALE, DISEASES OF THE. A knowledge of diseases of the breast is necessarily preceded by information as to mammary anatomy and physiology, since no organ of the body passes through more phases during its life. This information is furnished mainly in the preceding article; but there are still certain points in regard to which the writer desires to draw attention.

The mamma is a portion of the reproductive apparatus, and as such is of sufficient importance to designate a most extensive class of the animal kingdom in which it is present, mammalia. As would be expected, there is a certain concordance between the number of mammary glands with which an animal is provided and the number of young likely to be produced. The larger animals, *e.g.*, elephant, possess two breasts; the smaller, many. They are always met with normally in pairs, being ranged on either side of the middle line of the body anteriorly. In quadrupeds they are usually abdominal, but not always, the horse's being in the groin, and the elephant's in the pectoral region. While both sexes are provided with mammæ, they are so decidedly rudimentary in the male as to be deserving of no mention, and are of interest only pathologically, and exceptionally even then.

In the adult human female there are found two breasts, forming round eminences upon the front of the chest. These eminences are composed of the mammary glands enclosed each in its cellulo-adipose envelope and covered by integument, save where they are in connection with the thorax. From the third to the seventh rib, and from the axilla to the border of the sternum, is usually accepted as the position of the mamma, but to this there are many exceptions due to physiological conditions present at the time of observation. Over the fifth intercostal space upon the front of the breast, rather below the centre of the gland, the nipple (mamilla) projects forward and outward; surrounding the nipple, covering a circle two inches or so in diameter, there exists an area of darker hue than the rest of the breast (areola). The size and color of both nipple and areola vary greatly in different women, and also at different stages of pregnancy. The general shape of the mammary gland proper is that of a flattened pyramid, having the base somewhat concave, corresponding to the thoracic contour, and oval, the long diameter reaching toward the axilla. The horizontal section of a cadaver at the level of the nipples passes through the upper portion of the body of the eighth dorsal vertebra. The nipple forms the apex of the pyramid, the rounded contour of the breast depending upon the presence of subcutaneous fat. In the negress, the virgin mamma is more pointed and less rounded than in the white race.

In regard to the structure of the breast, it is only necessary to say, in addition to what has already been said in the preceding article, that the color of the glandular tissue is less yellow than that of the adjacent fat; it is also more firm; both facts of moment to the operator when excising a breast. It should also be remembered that fat does not exist between the chest and the mamma, and likewise it is wanting under the skin of the areola. Furthermore, while the skin covering the breasts is of fine texture, the areola, as well as the nipple, is studded with sebaceous glands, whose secretion protects the surface while the child is being suckled.

During pregnancy remarkable darkening of the nipple and areola occurs, and though after lactation the pigmentation somewhat lightens again, yet it never disappears. The general coloring of the woman influences the color of the areola, in dark women the change being more pronounced than in fair ones. The same rule holds for negroes and the mixed races, mulattoes, Indians, etc. The strong fibrous investment of the mamma is joined to the skin by connective-tissue. Posteriorly, equally strong connective-tissue (the suspensory ligaments of the older writers) holds the gland against the great pectoral muscle, and, if the mamma be large, against the serratus also. Beneath the pectoralis major are often found two or three small glands, which are very generally in relation with a large and constant gland, situated near the coracoid process (inward from it), beneath the attachment of the pectoralis minor. I have found this chain of lymphatics enlarged more than once in consequence of mammary cancer.

Capable of recognition about the third or fourth month of intra-uterine life, the mammæ, at birth, are well developed, and often contain a lactescent fluid which may escape for a day or two; from birth until puberty, in the two sexes, these glands pursue about the same course, the nipple being perhaps a little larger in the female. At puberty the mammæ in the male enlarge somewhat, and become painful, a thin fluid will occasionally exude, and a few hairs appear in the areola. In the course of a few months the glands return to their former quiet state. The enlargement of the breasts and nipples, the increase in size, and the deepening in color of the areola at the time of puberty in the female, present phenomena sufficiently familiar. These changes may precede or follow com

mencing menstruation. The gland has now reached a condition of passive maturity which is preserved until the cessation of menstruation. The occurrence of pregnancy awakens the gland into active maturity, never to regain its former condition (see Lactation). After a pregnancy the areola is permanently darkened, the nipple is enlarged, the sebaceous glands are prominent, and the connective-tissue of the breast is stretched so that the lobules of the gland are easily defined, while the breast is attached more loosely to the thorax, and the skin covering it may be wrinkled. There is a widely diffused opinion that lactation induces a flaccid condition of the breast, and that, to preserve the figure, the secretion of milk should be arrested as soon as possible after confinement. In scrofulous women, and those of lax fibre, this is true, but it is not so in all healthy, well-formed females. It would appear, also, as though there were certain race peculiarities; thus Hottentot and Indian women are reported to be furnished with such pendulous mammæ as to be able to give suck to an infant carried on their (the mothers') backs. A few hairs sometimes grow from the areola, not usually, however, except in nulliparæ. In this class, also, the subcutaneous fat is apt to be more or less removed by absorption. After the menopause, atrophy of the glandular tissue occurs, coincident occasionally with a large deposit of fat about the part. Atrophy rarely takes place in all lobules exactly at the same time; hence there will be present a slightly lumpy or nodular condition which is not to be mistaken for a new formation;—the fatty deposit mentioned above, by producing apparent increase in size, aiding such an error. Asymmetrical development of the breasts at puberty is exceptional, but is occasionally noticed; it is but a temporary condition, and usually need cause no anxiety. Absence of function in one breast is extremely rare; in such a case one breast will do duty for two. An instance is on record of four sisters whose left breasts secreted no milk after pregnancy.

Entire absence of mammary glands is extremely rare—amazia—and is accompanied by other deformities usually incompatible with life. Absence of one breast is more often met with, and the corresponding ovary is found to be wanting as well (Scanzoni), or the great pectoral muscle of the same side. Probably absence of one breast and deformity of the other is the nearest approach to amazia found in the adult.

Supernumerary mammæ (Polymastia) are not uncommon. Bruce,[1] in 4,000 examinations, found this deformity present in 1.54 per cent., a ratio greater than usual, I believe. He also finds men more often affected than women, in the proportion of 4 to 1, a result contrary to that obtained by Godfrain.[2] I have seen the deformity more often in females. Axillary prolongations are not infrequently met with, and may be mistaken for lymphatics. They undergo the usual development during pregnancy, the secretion escaping by the nipple. Supernumerary mammæ occur most frequently in pairs, and are situated below the normal glands, rather nearer to the middle line of the body; the situation next in frequency is above the normal glands and further from the middle line, *i.e.*, toward the axilla. When the deformity is unilateral, the left side is most often chosen. Supernumerary glands below the normal mammæ are larger and better supplied with nipple and areola than when situated on the side toward the axilla. They of course follow the evolution of the natural gland, becoming most apparent during lactation, and undergoing atrophy after the menopause. Klob has recorded an additional mamma, on the shoulder, the size of a nut; it was provided with a nipple. Two examples have been noticed on the back. Robert reports an instance upon the thigh; Percy, one upon the epigastrium. Multimammæ are not over fecund, and may or may not be provided with nipples for the additional glands, or the secretion may escape by a small opening. Functionally also there may be great variation. Ross[3] reports a mulatto with a third breast beneath the normal left one. It was six inches in circumference, was provided with nipple, follicles, and areola, yielded milk, and if not attended to was painful from over-distention. The nipple was too small for the child to nurse. Lynceus[4] reports a woman with four breasts in two vertical lines. All gave milk abundantly. Gardner[5] a similar case in a negress, the supernumerary glands being in the neighborhood of the axillæ. Percy[6] reports the case of a vivandière who had four mammæ in two vertical lines, and a fifth five inches above the umbilicus, in the middle line. This latter resembled the breast of an impubic girl; the other four secreted milk.

Alexander[7] records the case of a mulatto male with six nipples in two vertical lines, there being a distance of four inches between the nipples vertically. The subject of the report stated that his mother was malformed in like manner, four of her nipples giving issue to milk; also, that, of several brothers and one sister, all save one brother were provided with four supernumerary breasts. Unfortunately these statements could not be verified by an examination. Robert's[8] case, already referred to, is as follows: A woman, whose mother had three breasts, herself had a supernumerary mamma upon the outer surface of the left thigh, four inches below the great trochanter Her own child sucked the additional mamma for twenty-three months. Four foster-children nursed from it during six years. Robert examined this mamma and found it atrophic like the (pectoral) others, the menopause being past. Handyside[9] reports three brothers each with four mammæ. The parents were normal. Variations, both as regards nipples and areolæ, are observed to occur, not only in connection with additional breasts, but also with mammæ in the usual situation and otherwise normal. G. Honnaüs saw five nipples to one breast. Imperfectly developed nipples, or indeed entire absence of nipples, is more common, and this condition is the cause of much pain and inconvenience, owing to the infant being unable to nurse properly, and so inducing engorgement, with consecutive inflammation of the corresponding mamma. Congenital abnormalities of the mamma are hereditary. They have been seen, according to my experience, more often in the negro and mulatto than in the white race.

Hypertrophy of the mamma is seen in both sexes, occurring in one or both glands. The lymphatic and scrofulous are more likely to be so affected. As a sequel of mumps, it may accompany atrophy of the corresponding testicle. Olphan quotes[10] from "Soc. de Biologie" the case of a man who lost a testicle from cancer, and subsequently died from a recurrence of the disease One breast was enlarged, and showed, on microscopic examination, colostrum and milk-globules. Gorham[11] records the following case: The patient, a soldier, received injuries in battle, and acquired Pott's disease of the upper dorsal and lower cervical vertebræ. Atrophy of the testes was observed, and coincidently progressive enlargement of both breasts took place. Sexual desire was in abeyance after the spinal injury. Four and a half years subsequent to the accident, Gorham says: "Each breast is at this period the size of an orange, glandular to the touch, and pendulous." Prior to the spinal hurt, the patient had three children by his wife; subsequently, his figure and appearance changed, resembling that of a eunuch. This case appears to be the one reported by Thompson[12] previously. Unilateral hypertrophy has not been noticed coincidently with non-descent of one testicle. Petrequin ("Labarraque, Thèse de Paris," 1875) saw a man with a pendulous mamma, forty-eight centimetres long; no cause. Enlargement of one breast in young boys has been noted as occurring without cause, but such increase may be simulated by retro-mammary lipoma, as in the instance recorded by Lobker.[13]

Hypertrophy of the mamma in the female has been noticed a number of times. Inasmuch as there are physiological variations in the size of the mamma, it is not easy to say just when enlargement becomes pathological. The breasts have been found to weigh many pounds, constituting enormous tumors pendent from the front of the thorax, sufficient, indeed, to prevent locomotion, to any extent, on the part of their unfortunate possessor. In Huston's[14] case the right breast weighed twelve pounds, the left, twenty pounds. Demarquay[15] removed a left mamma, after second pregnancy, weighing eight

kilogrammes. Skuhersky[16] records mammæ of eighteen pounds and nineteen pounds. Esterle,[17] in a case which came under his observation, judged the breasts, in the third month of pregnancy, to weigh from twenty-six to thirty pounds, confining the patient to bed. Chassaignac and Richelot report an instance of a breast which weighed thirty pounds, and hung down as low as the knee. Durston[18] made an autopsy of a girl whose right breast was supposed to weigh forty pounds, and whose left actually did weigh sixty-four pounds. The skin covering such enormous masses as these will, of course, be greatly stretched and somewhat yellowish in color, usually roughened also. A certain woman was married in 1853. After two pregnancies the left breast was so large that it reached to the umbilicus, and was removed in 1858. After removal it was found to weigh sixteen and a half pounds. The following in regard to it is from Schmidt's "Jahrbücher," t. cvi., p. 51, 1860: About two litres of milk, very white, flowed from the tumor, showing here and there a streak of blood, without odor, alkaline, thick, resembling good cream; specific gravity, 0.98 to 0.99. Quantity, analyzed by Professor Schlossberger, showed: Water, 67.52; fat, 28.54; sugar and extractive matters, 0.75; casein, 2.75; salts, 0.41.

The tumor was examined microscopically, and from this examination it appeared that "the stroma was made up of fibrous connective-tissue split roughly, the cells communicating with each other by numerous projections, containing, here and there, fatty granulations. The small vesicles of the acini, pear-shaped, rounded, or elongated, . . . were slightly longer than normal, and enclosed, as did the commencing excretory canals, many small bodies having a well-defined outline, and containing shining nucleoli, and a large number of fatty globules. The larger excretory canals presented the usual structure. The lumen walls were made up of compact fibrous connective-tissue, mixed with cells, but without trace of glandular elements. Epithelial lining was lacking. The origin of these cavities was due, very probably, to a partial dilatation of the tissue by accumulation of its contents, which had brought about, on the one hand, destruction of gland substance, and on the other, a new formation of connective-tissue." Demarquay's case, already referred to, showed on microscopic examination fibrous degeneration. There existed, in the extirpated breast, a central cavity containing serosity in which were small oil-globules, granular globules, and blood-cells.

Cause.—Nothing certain is known as to the cause of this increased growth; menstrual irregularity or actual suppression has seemed to be the exciting cause. Increase with each succeeding pregnancy is noted. In Huston's case the ovaries were found diseased. Recognizing the close relations between the different parts of any system in the human economy, it is fair to infer some general disturbance of the generative apparatus prior to the onset of mammary hypertrophy, but of what character such disturbance is, we are for the present in doubt.

Between the ages of fourteen and thirty the affection under consideration is most likely to occur. While both breasts have been hypertrophied, the left seems to show a greater predisposition to such hypertrophy. An extremely interesting example of temporary[19] increase in bulk, the erection of mamma, during a paroxysm of intermittent fever, is noted by Ferrus (Gaz. des Hôp., 1846, No. 90, p. 358); it yielded to quinine. At the onset of the trouble the mammæ are large and firm; subsequently, however, they are pendulous, and thus appear pedunculated; the lobes are easily distinguished, the areola is large, sensibility is lessened, and perhaps there may be some œdema at the depending portion. The beginning of the disease is insidious, and its progress is characterized by alternations of rapid increase and apparent quiet; entire retrocession is not observed. Durston's[20] case was very rapid, death closing the scene in three and a half months. After delivery, should hypertrophy commence during pregnancy, growth ceases. In Huston's case, gangrene followed a blow, death ensuing. MacSwiney[21] relates a case in which removal of one breast made the other grow faster.

The *prognosis* is not grave, except when the mammary increase is accompanied by general emaciation, with frequent pulse. Esterle[22] met with such a state of affairs, and found opium to give relief up to the time of confinement, when improvement took place. It is possible that the induction of a miscarriage would be necessary, other means failing, but this should be done only when the life of the mother is gravely imperilled.

The indications for *treatment* are both local and general. If menstruation be absent, induce it; if it be too profuse, diminish it; if it occur during lactation, arrest it; should arrest of lactation be the exciting cause, then re-establish the secretion;—in other words, keep the generative apparatus normal. Iodine and iodide of potassium, internally and by friction, are indicated. Locally, support and compression by rubber bands will be found useful. Other means failing, removal of the ovaries, or the ovaries and tubes, by establishing the menopause, might bring about a cure of the trouble under consideration. I am not aware that this last treatment has ever been adopted; it is, however, physiological, and worthy of trial.

Where growth has ceased and the size of the mamma is inconvenient, amputation is indicated, as in a case already quoted.

Variation in the physiology of the mammary glands is not less marked than the anatomy. Secretion soon after birth is not so very uncommon, and in a case recorded by Stephen,[23] abscess followed its retention. Baudelocque[24] notes a girl, aged eight, who suckled a brother, and Audibert,[25] a woman, aged sixty-two, with active mammæ. J. Young notes absence of milk in the left breast of four sisters; for a full account of the subject the reader should consult the article Lactation. The sympathy existing between the breasts and other parts of the generative apparatus is too well known to need more than passing mention—instance the mammary pain during menstruation, often observed.

Diseases of the Nipple.—The nipple, save in lactation, rarely attracts notice; during the active life of the mamma, however, it is far otherwise. Its physiological perfection is a matter of extreme moment, not for the mother only, but for the health of the infant. A well-formed nipple of sufficient size, not buried deeply in the areola, but standing out from the skin surface, is to be secured before the end of pregnancy. Should this development not occur during the last months of gestation, gentle traction upon the nipple, with pressure backward on the areola, will be of use in aiding protrusion. Suction by means of an air-pump has also been tried.

After the termination of labor, two causes are paramount in causing nipple disease. 1, Lack of development; 2, lack of cleanliness. The first offers an obstacle to the emptying of the breast, while the effort of the child to suckle excites the mamma to active secretion; there results retention and engorgement. The second conduces to an unhealthy condition, with a long catalogue of skin diseases, erosions, fissures, etc. Not only, then, is the protrusion of the nipple to be assisted, in the manner described above, but the tender skin covering it and the areola should be hardened by frequent cool bathing during the eighth and ninth months of gestation, or, perhaps, by the employment of a slightly astringent lotion.

After the child nurses, the nipple and areola are to be gently and thoroughly cleansed, in order that the baby's saliva or a little milk, etc., may not rest in the natural rugæ of the part, and so induce irritation or a worse condition. Erythema and eczema present no symptoms not seen elsewhere; ecchymoses, from the child's suction and chewing while suckling, are recognized by the ordinary signs. Paget has described a chronic eczema which has its starting-point in the nipple; after destroying the latter, the disease gradually extends both over the surface and into the substance of the mamma, and finally terminates in carcinoma. Investigation seems to negative the simple character of this eczema, and it is known as malignant papillary dermatitis. The exact nature of the disease cannot yet be considered as settled upon an anatomical basis. The prominent characteristics are: a bright red

raw surface, slightly raised, with a well-defined border; to the touch, a certain firmness or parchment induration; secretion scanty; existence very chronic. The areola and nipple are affected; the latter disappears and is replaced by a crater-like depression. By extension along the milk-ducts, carcinoma of the mamma is established; topical applications have not hitherto been of use. When the disease under consideration is established, extirpation, as soon as the diagnosis is assured, should be done.

Fissures, erosions, etc., when first established, are best treated by slightly astringent applications, afterward by emollient washes. Later, after the child has nursed, the breast may be washed, dried, and powdered with bismuth subnit., lycopodium, etc. I have seen excellent results follow the application of pure rubber, dissolved in chloroform, to the fissures, before the child is allowed to nurse. The application of a four per cent. solution of cocaine is reported as giving excellent results. Shields and artificial nipples of one kind or another may give good results, or the secretion of milk may require suppression, in order to bring about healing. Abscess of the nipple is infrequent, and, according to Velpeau, occurs in a milk channel most often; under such conditions milk will escape after the discharge of matter. Rarely more than a drop or two of pus is formed.

Chancre of the nipple and areola are usually acquired by inoculation from a mucous patch, and resemble chancre of the lip. The amount of induration is very marked, not, however, appearing suddenly; parchment-like at first, the induration spreads to subjacent tissues, and may involve an area equal to that of a silver dollar. If the breast is being nursed, a scab is not allowed to form; otherwise a covering crust is not unusual. The primary lesion of syphilis may appear as an erosion, fissure, or ulceration. An axillary bubo will exist, more often just under the edge of the great pectoral muscle rather than deep in the axilla. The progress of the chancre is slow and painless, changing with the advent of secondary accidents into a mucous patch. During the early stage only of the disease will there be room for doubt; absence of pain, however, a raw surface existing, is to be looked upon with grave suspicion. A nursing woman being affected, the mouth of the infant she nurses is to be scrutinized closely.

Hyperæsthesia of the nipple, accompanying a rigid condition of the organ, has been noted, and will probably depend upon disturbed function of the uterus and appendages.

A similar hyperæsthesic condition of one or both breasts may be met with, and is likewise dependent upon an artificial mode of life, inducing defective menstruation.

Neuralgia of the breast, the so-called irritable mamma, is to be classed with the two preceding affections, and is the outgrowth of incomplete or deranged sexual life. The subjects are usually unmarried, but not always; young, under twenty-five years, slender, with pale complexion, of lax muscular fibre, and not dependent on their own exertions for a livelihood. They will show strong predilection for trashy literature and laziness, rather than for the standard authors and exercise; the ism of the day will prove a subject of absorbing interest. Other hyperæsthesic spots or lines generally exist upon the skin of such individuals, along the spine, for instance, or over the intercostal nerves, and certain attitudes or motions will be complained of as liable to induce great suffering. Some sorrow may have been experienced, and the subject of it, from overmuch thought, gradually develops sympathy for herself, changes her mode of life, and generates a mammary pain. Physical examination of the breast shows no cause for suffering.

Treatment consists in regulating menstrual life and causing the patient to pursue an active and useful existence. In my hands, far more success has been thus attained than by resorting to, and relying largely upon, drugs. Menstruation, whether excessive or deficient, is to be rendered normal by appropriate means. An action of bowels once daily is to be secured, diet should be simple, nutritious, and not in excessive quantity; clothing should be warm and loose, not confining natural movements; the function of the skin should be assisted by cold sponging, regular exercise insisted on, the patient should retire to bed early and rise early, dime novels put aside and the classics read, so that both mind and body are gradually led to a normal healthy condition, the mammary pain departing meantime. Briefly, the treatment may be stated in the old saying, "Live on sixpence a day and earn it."

Contusions of the mamma are of interest as having given rise to malignant disease in a certain number of cases. In order properly to estimate violence as a factor in the etiology of carcinoma or sarcoma, the number of bruised breasts not the seat of malignant growths should be known. This is manifestly impossible, and with our present knowledge we must remain in doubt concerning violence as a factor in the etiology of malignancy. Ecchymoses without traumatism have been observed in women menstruating with difficulty, blood also oozing from the nipple, perhaps.

Wounds of the mammary gland bleed freely; parenchymatous hæmorrhage and much oozing follows. Pressure with sponges or cloths wrung out in hot water is the most efficient hæmostatic; healing is not rapid and pus-formation usual.

Inflammation of the breast—mastitis—may occur at any age, but is found far more often during the early days of a first lactation than at any other time. It is no uncommon circumstance for the mammæ at birth to be somewhat swollen and to give exit to a small amount of discharge more or less milky in character; if let alone, no harm follows. Injudicious handling on the nurse's part to "work out the milk" is almost always indulged in with the result of causing an abscess somewhat often. Up to and including early puberty mastitis is rare, and when present is apt to be chronic rather than acute. The subjects are girls of feeble muscles, pasty complexion, torpid bowels, etc., and present those symptoms generally grouped under the term strumous. Early opening of the abscess, general tonics, and out-of-door life, with regular hours, suffice for a cure. During pregnancy and the normal mammary development consequent thereon, save from traumatism, abscess is very rare; but with labor the scene changes; mammary inflammation and abscess occurring most frequently during the first month of lactation depend, in the great majority of cases, upon a defective development of, or morbid condition of, the nipple. The nipple is so small that the child grasps it with difficulty, suckling is imperfect, and the mamma is not emptied; or a cracked and fissured nipple is so painful, when grasped by the baby's mouth, that suckling is again imperfect, or from the inflamed nipple through the lymphatics, trouble is induced at a distance. The inflammation and abscess met with in early lactation are recognized as occurring, first, superficial to the gland—subareolar; second, beneath the gland in relation with the thorax—submammary; third, in the connective-tissue of the mamma—interlobular. To these three classical situations I will add a fourth: in a lacteal sinus, which, although not met with so soon after birth as the others, is worthy of recognition.

The cause of mammary abscess is not difficult to find. Pregnancy calls into life a hitherto comparatively rudimentary organ for the performance of an active function, and failure of any part of the organ determines an accident. The nipple, a healthy condition of which is essential to proper escape of the mammary secretion, is subject to violence, etc., from the infant, and an inflammatory accident follows, by continuity of tissue or lymphatic transmission.

A subareolar abscess, not larger than a filbert, is found in the connective-tissue of the locality implied by the name, and is recognized by the usual signs. An early incision is indicated, in a direction radiating from the nipple to the periphery. I have never been able to appreciate the humanity of waiting until a mammary abscess "points;" great pain is thereby entailed upon the unfortunate woman, and the function of the breast is kept in abeyance, or perhaps permanently impaired. The

many means for obtunding suffering now at the surgeon's command render procrastination most injudicious from a painsaving point of view, if from no other. Submammary abscess is rare; a collection of pus forms in the connective-tissue joining the breast to the great pectoral muscle. Inflammatory fever is apt to run high, movement of arm and chest muscles increases pain, and the whole breast is pushed forward, is tense, retains its contour, and imparts to the examining hand a sensation as though the mamma rested upon an elastic cushion; fluctuation at the periphery of the breast may sometimes be felt, late in the affection. Large veins will be seen wandering in the skin covering the breast. This variety of abscess may be caused by an interlobular mastitis, by an axillary abscess, by a carious rib, or by the bursting of an empyema through the chest-wall. An opening is best made, *in the absence of some special indication*, below and to the outer side. The incision should be of moderate length, and a director should be introduced into the wound as a guide for the dressing-forceps, which should be withdrawn open in the usual manner. The use of a drainage-tube is expedient, and should free exit for inflammatory discharge not be afforded by one opening, then another is indicated. The breast should be well supported and pressed against the chest by a bandage or by strips of adhesive plaster. Should an empyema or carious rib exist, treatment proper for it is to be instituted. Inflammation of the gland proper or of the interlobular tissue follows engorgement consequent upon a cracked or excoriated nipple, or, indeed, upon any cause preventing free discharge of milk. A sense of discomfort is soon followed by pain, etc., and fever is very marked. Occasionally a chill ushers in the disease. The interlobular tissue is first attacked, and the inflammation may extend between several lobes, or to the sublobular tissue. The strong capsule of the mamma opposes extension toward the skin, and pointing occurs late, pending which the glandular tissue may become involved and suppuration in it occur, permanently impairing the affected lobe or lobes. Fluctuation is not found early, and should not be awaited; acute pain somewhat localized, hardness, and elastic tension, will suffice for a diagnosis, and will justify a puncture, followed by incision if matter escape. In this form of abscess, as well as in others, a sensitive and enlarged gland may be met with in the axilla. Should artificial opening be deferred, the matter slowly approaches the surface and then points rather suddenly. Successive abscesses may form in the mamma, as the inflammation slowly extends from one place to another.

Successive formations of pus-dépôts, following acute mastitis, are indications of a too limited opening, with incomplete discharge of matter. During acute inflammation a mamma should not be nursed by the infant, but lacteal engorgement must be carefully prevented by the diligent use of a breast-pump; it is usually not necessary to entirely arrest milk formation by drugs, etc., unless a discharge of pus by the nipple is chronic or the abscess shows no disposition to heal. Acute inflammation of a lacteal sinus is infrequent, occurs usually long after the puerperal condition is met with, in anæmic patients, and follows interlobular mastitis, or more often, perhaps, obstruction of the outlet through the nipple. Probably a catarrhal inflammation of the mucous membrane is present. The prominent symptoms are: pain over the sinus, which increases with distention; discomfort on pressure usually; and, during quiescence of the gland, pressure will cause pus to exude from the nipple. The two instances in which I have recognized this condition were treated in various ways, but the mammary secretion disagreed with the nurslings and it became necessary to arrest lactation in order to effect a cure.

It has been already said that the incision to evacuate pus from a mammary abscess should be made in the direction of a line drawn from the nipple toward the periphery of the gland.

Chronic abscess is sometimes, though rarely, met with, and is more apt to be confounded with scirrhous carcinoma than with any other morbid condition. It begins deeply in the gland, and incorporates surrounding parts by firm exudation; later, the nipple may be somewhat retracted, the skin dimpled, reddened, and adherent, also the axillary lymphatics may be enlarged and tender. Women whose health is poor and nutrition defective are usually affected. A diagnosis, differential, between chronic abscess and scirrhus, is sometimes so difficult as to require an incision. The treatment is free incision, generous diet, and general tonic regimen. Port, beer, or porter will assist recovery by strengthening the patient. Tuberculosis of the mamma, with our present knowledge, would probably escape recognition. A tumor slowly suppurating, leading to the formation of sinuses with undermined edges, in a subject of tuberculous tendencies, would excite suspicion which the microscope would be called upon to confirm, by disclosing the bacillus. Extirpation will be, of course, the proper treatment; sinuses should be "spooned" and iodoform applied. In a certain number of women a breast which has been the seat of abscess becomes the seat of malignant disease subsequently. I have not been able to see that the two conditions bore to each other the relation of cause and effect. For, while carcinoma is found in a breast which has been the seat of mastitis, yet many mammæ, which have been similarly affected, do not develop carcinoma. I have noted a carcinoma in one mamma which had always been healthy, the other breast having suffered from inflammation after confinement. It is natural to suppose that, if much induration remains permanently after mastitis, malignant disease would be more apt to develop than if no such induration were present.

Classification of Mammary Tumors.

With our present knowledge of mammary tumors, it may be safely said that any classification is but provisional, and will need modification from time to time, as additional facts are added to those already known. Tumors may be considered as indicating new formations and cysts, alone or in combination, and are best grouped according to their anatomical elements. It is unfortunately a fact that the clinical history of a growth cannot be stated so soon as the histology is known, but it can be done far more accurately now than was possible some time since, and more accuracy is daily being attained. I submit the following:

I. Cysts.

II. (*a*) Tumors resembling fully developed connective-tissue: fibrous tissue, fibroma; adipose-tissue, lipoma; mucous tissue, myxoma; bone, osteoma.

(*b*) Tumors resembling embryonic connective-tissue: sarcoma.

III. Tumors resembling epithelial (secreting) tissue: carcinoma.

IV. Tumors resembling the more complex higher tissues: gland-tissue, adenoma; nerve-tissue, neuroma; vascular tissue, angioma; the two latter so rare as to be disregarded.

Of the foregoing tumors, sarcoma and carcinoma are classed as malignant, the others as non-malignant or benign. Carefully kept clinical records, supplemented by accurate anatomical research, are greatly needed in the study of mammary growths, and the absence of such records renders much experience in the past quite useless at the present time. Probably no one word has brought about this result so much as the term "cancer," which is used either clinically, or anatomically, or as a means of concealing ignorance, by different observers. Clinically it means malignant, anatomically it means carcinoma; to avoid misunderstanding, the term will not be employed.

Cysts are sacs enclosing fluid more or less thick. A lacteal cyst—galactocele—is a tumor containing milk, normal perhaps, but more often having undergone changes during retention. A sinus or duct becomes closed, and is gradually dilated by milk as fast as it is secreted. The tumor begins, as a rule, beneath the areola, without inflammation, and with little pain, and extends toward the periphery, usually in a nursing woman. Should the occluded duct be in a lobule, the tumor will commence deeply, and at a distance from the nipple. Increase at first is rapid; later, however, if lactation cease, diminu-

tion in bulk occurs, the cyst parting with its fluid and becoming more solid; its contents will then be curd-like, consisting of epithelium and fatty matters. Lacteal cysts have been noted of enormous size; they are usually single, and do not discolor or involve the overlying skin unless inflammation supervene. In a case observed by me tension of the cyst varied with the active or passive state of the gland. Pain is very rare, and the size of the breast is complained of only. The general outline of the cyst is oval and smooth, more rarely lobulated. This latter shape is due to rupture of the wall at some point, and escape of contents which become encapsulated in connective-tissue. The diagnosis offers difficulty only when, from long retention, the cyst-contents have become more or less solid; but even then the previous history enables the surgeon to usually avoid mistakes.

In a nursing woman, puncture or aspiration relieves temporarily, but does not cure, for the cyst refills quickly; injection with iodine tincture is equally inefficient. A free incision, followed by suppuration of the sac, or extirpation of the cyst, are the most reliable methods of cure; of the two, probably extirpation is the less painful. In a non-nursing woman aspiration, followed by injection of iodine tincture, offers more chance of cure, and should be tried, but the more radical measures mentioned above will probably be resorted to.

Non-lacteal cysts occur before and after the menopause, and result from the obstruction and subsequent dilatation of one or more ducts. Such cysts are usually multiple, not large, scattered through the gland, and contain a fluid more or less thick, secreted by the lining membrane of the dilated duct. This fluid may be clear or colored; and these colored cysts, in which the colors red and yellow predominate, are found more often in advancing years than at an earlier period. In the nursing woman the cysts under consideration are rare; they are met with in sterile women, or in those who have long ceased to bear children and approach the menopause. Pain is exceptional, but weight and discomfort are complained of. Increase is slow and gradual; lymphatic implication is never seen. The diagnosis is made with difficulty; and, after all, that is a matter of small importance, since extirpation alone promises relief, if multiple cysts exist. Discharge from the nipple is a not infrequent accompaniment of cystic growths. Large single cysts are usually found near the centre of the mamma; multiple cysts, generally small, occur more often near the periphery. Both breasts are sometimes affected, but never to the same degree. Obstruction of a duct, causing the cyst, occurs in the old, probably from contraction of the fibrous stroma, while in youth defective evolution—excessive—of an acinus is invoked as a cause; hence the terms "involution cysts" and "evolution cysts," as they are called. The diagnosis rests on the slow growth, shape, consistence, and multiplicity, on the absence of glandular enlargement in the axilla, and, in case of puncture, on the escape of contents. When many cysts exist removal of the breast only will afford relief; a single cyst may be opened, suppuration induced, and a cure by granulation obtained. Hydatid cysts of the breast are extremely rare, and the growth being slow, this variety will usually be confounded with a retention-cyst. On incision, daughter cysts may be seen, or hooklets may be found with the microscope. Healing by granulation after discharge of the hydatid is to be expected.

Cysts in relation with tumors will be found under the heading of the appropriate new growths.

Extravasation of blood, which may become encysted, has already been referred to. The ordinary wen—sebaceous cyst—occurs rarely in the breast, and attains but small size.

Tumors Resembling fully formed Connective-tissue—Fibroma, Lipoma, Myxoma, Enchondroma.—Of these the first-named is much the most frequently met with; indeed, it is much the least rare of benign mammary growths. It is composed of hyperplastic connective-tissue, together with glandular elements, more or less imperfect. It is this latter circumstance which has given rise to confusion, the terms adenoid, fibro-adenoma, adenocele, being used by various observers. The fibroma may enclose one or more cysts, from dilatation of contained ducts, or may project into a duct which becomes dilated, thus appearing as an intracystic tumor. More precise information will be found under the heading Tumors.

Fibrous tumors are observed during the period of active menstrual life, preferably between the ages of sixteen and thirty, yet instances have been recorded as early as twelve and as late as fifty-six years. An overgrowth existing in an active organ would be expected to induce pain and impair function; and the first expectation is verified in many cases, for pain in the breast during menstruation and pregnancy is common; during menstruation and pregnancy, also, increase in size of the tumor may occur, to subside as the gland regains physiological rest. Hereditary predisposition is not apparent, and it is a singular fact that the negro, in whom fibroma uteri is very often found, is very rarely the subject of circumscribed fibroma mammæ The variety of growth under consideration presents itself as a circumscribed, rounded mass, firm and elastic to the touch, with here and there, perhaps, a protruding boss, in which fluctuation may be apparent, indicating cystic association. The most usual site is at the periphery of the breast, above the nipple, where the tumor will be found projecting under the skin; deeply within the gland a fibroma is more apt to be intracanalicular. Variation in tension of a cyst, from absorption of its contents, will cause an apparent change of consistence in the tumor. A capsule is usually present, but where much glandular tissue is joined with the fibrous—*e.g.*, in intracanalicular growths—the capsule is not complete. Neighboring tissues move freely over the growth. Section shows interlacing bundles of white fibrous tissue, with moist surface, and also, perhaps, acini or ducts dilated into cysts. While these fibroids usually occur singly, several may exist in one breast, or in both breasts simultaneously; they only exceptionally attain great size. The rate of growth is slow in solid tumors, but more rapid in the cystic variety; a sudden and very rapid increase is almost certainly an evidence of the cystic character of the tumor, and will cause change in its shape; cysts are more apt to occur (cysto-fibroma) toward the end rather than the beginning of menstrual life. A discharge of serous fluid from the nipple may occur with an intracanalicular growth; when the fluid is bloody, telangiectatic formation, or rapid growth with increased vascularity is probable. Adhesion of the growth to the skin, or surface ulceration, occurs as an accident only. The neighboring lymphatics are not involved, and though a recurrence may be, and is, observed in rare cases, yet such recurrence is as a local growth without tendency to infiltrate adjacent parts. Fibroma rarely undergoes degenerative change—fatty, myxomatous, and cystic changes being the most frequent. So far as regards danger to life, a favorable prognosis is indicated. The treatment proper for fibroma is removal by incision, so directed as to interfere as little as possible with mammary function.

Lipoma and enchondroma are not met with in the mamma, or so rarely as to be museum curiosities. Submammary lipoma has been seen, however, a certain number of times, and in nowise differs from fatty tumor elsewhere in the body, save, perhaps, that in early life it has been more frequently observed. The diagnosis and treatment are the same as in other parts. Myxoma is rare, and presents itself in the breast as a single, rounded, perhaps bossed tumor, usually in the upper half of the breast. On section it appears as a light-colored, jelly-like mass, yielding apparently mucin—hence the name. Not infrequently fibrous, vascular, or fatty areas exist in the growth. The tumor originates in the connective-tissue between the lobules and is usually encapsulated. The latter half of menstrual life is the chosen age. Inflammation occurs exceptionally, but may induce ulceration of skin already infiltrated or stretched, with, perhaps, protrusion of the growth, which is movable usually in the mammary tissue and also upon the thorax. Increase is more rapid than that of fibroma, and consistence less firm; a cyst, if present, will not be recognized very easily. Involvement

of both breasts (simultaneously) is not seen. Retraction of the nipple is not observed, pain is wanting, and adjacent lymphatics are uninvolved. An incision will usually be required in order that the diagnosis may be made. Removal of the tumor by careful dissection will sometimes be followed by a recurrence *in situ*; removal of the entire gland is, therefore, indicated, together with any involved skin.

The term malignant, applied to a morbid growth, is used to indicate a tumor differing histologically from the tissue in which it is situated, having a tendency after removal to recur *in situ*, and having a tendency to reproduce itself in distant parts of the organism.

Sarcoma is a tumor composed of cellular elements of the connective-tissue type, which do not develop to maturity but remain embryonic; an intercellular substance is present, though but in scant quantity, and there is a new growth of vessels.

Sarcomata are named according to the character of the cells of which they are mainly composed: spindle-celled, round-celled, myeloid, lymphoid, etc. Not infrequently different parts of the same tumor show variations of cell growth, and with some this is the rule, *e.g.*, with myeloid tumors, in which the giant-cells (myeloplaxes) rest in a spindle- and round-celled stroma (for histology see Tumors). Rarely seen before the establishment of menstruation, sarcoma invades the breast by preference between the ages of thirty and forty years, appearing infrequently after the cessation of menstrual life. In this respect it differs from carcinoma. Spindle-celled sarcoma is most often met with at an earlier age than other varieties. I am unable to connect the sterile or multiparous state with the etiology of sarcoma, although the relation with menstruation has been referred to. Traumatism is the unmistakable starting-point in certain cases; antecedent inflammation, save in very exceptional instances, is lacking. Carcinoma I have noted as commencing in an induration left by puerperal mastitis; such an experience with sarcoma I do not recall. The upper half of the breast is more often affected.

In its general outlines sarcoma of the breast is rounded, oval, etc., and there exists a capsule which does not shut off the tumor from surrounding parts, so as to prevent extension; the capsule is formed of connective-tissue pushed aside by the increasing tumor, and is infiltrated by its proliferating cells; outside of the capsule there are to be seen (microscopically), principally along the vessels, numerous cells, which I believe are already impressed with the character of the original tumor, or are directly offshoots from it, and develop into a similar neoplasm. The insufficiency of any operation which attempts to effect a cure without destroying such an area of infection is patent. The shape of the sarcoma varies with the rapidity of its growth, there being always a tendency to increase in the direction of least resistance; sudden change in outline indicates a giving way of an opposing structure, cyst-formation, or else extravasation of blood from a ruptured vessel; a general rounded outline will be preserved, however. Trauma may give rise to extravasation of blood and consequent change of shape, but here the history aids the diagnosis. The growth of sarcoma varies much, and bears a certain relation to its anatomy, the spindle-celled variety being of slowest growth and firmest consistence, and having a more perfectly defined capsule; while, on the other hand, a round-celled sarcoma is softer, grows rapidly, presents often rounded outcroppings, and the new-formed vascular channels are apt to rupture and permit extravasation, not in one only but in several places. Cystic formation may cause sudden change of shape. Variation in rate of increase characterizes sarcoma; a nodule may remain for years without exciting suspicion, and then, from no known cause, grow with extreme rapidity. It is not usual for rapid growth to be succeeded by slow increase, but nevertheless this has been observed. When cystic or other degeneration occurs, slow growth is not to be expected, but rather continuous progress; and the same is to be said when extravasation occurs, save from trauma; inflammation occurring is apt to induce quick growth.

Increased temperature is noted in rapidly growing sarcomata. The volume sometimes attained is enormous, tumors of many pounds in weight being recorded.

Sarcoma is usually single, and very rarely affects both breasts simultaneously.

Adhesion to the chest-wall is not usual, although the tumor be of extreme size; on the other hand, implication of the great chest-muscle is seen, but not so frequently as with carcinoma. A protrusion through an intercostal space into the thorax has been observed.

Implication of the chest-muscle will be recognized by investigating the mobility of the tumor when the great pectoral is tense and relaxed alternately. The skin, although greatly stretched, is generally movable over the neoplasm for a long time, and may be discolored red or purplish. Ulceration of the skin from pressure of, and incorporation with, a subjacent growth is much less often seen than with carcinoma. When, however, the skin has given way, fungous protrusion is usual; the nipple is not affected, and a serous or somewhat blood-stained oozing, which has been observed in many cases, indicates involvement of ducts in or by the morbid growth; hence it occurs with cysts.

Pain is often complained of, not, however, in my experience until the tumor had attained a certain size. When ulceration is present, a certain discomfort is to be expected. I am inclined to attribute the occurrence of pain to pressure and traction upon nerves, rather than to the fact of their being involved in a rapidly growing tumor. Pain is referred to the arm in certain cases.

Lymphatic enlargement is rare in sarcoma, and when present, is due to irritative rather than to specific implication of the glands. Axillary bubo is therefore not often seen, and if present, would raise a suspicion of carcinoma. The presence of ulceration, either from implication of skin in the morbid growth or from irritating applications, is often followed by hyperplasia of the adjacent lymphatic glands.

It is believed that sarcoma becomes generalized by vascular channels rather than by lymphatic; hence the apparent immunity of the axilla in advanced disease.

General infection (sarcomatosis) is recognized by the formation of metastatic tumors. The lungs, presenting the first set of capillaries which sarcoma-elements would meet after entering the circulation, would be expected to frequently be the seat of secondary growths, and it is so. It is not possible to say at what time secondary tumors are most likely to appear, but it is always wise to question the lungs before operating upon a sarcomatous breast, lest a pulmonary metastasis be present, and the operation do harm by reducing the patient's strength. Local recurrence after operation is frequent, and while it is not possible to state the percentage in which return *in situ* is to be looked for, yet it can be accepted as the result of clinical observation that the softer and more rapidly growing a sarcoma is, the more likelihood exists of recurrence; conversely, the firmer and more slow-growing the tumor is, the less chance is there of return.

From the foregoing, one would expect a round-celled sarcoma to justify a more unfavorable prognosis than a spindle-celled one.

Cystic formations are present in many sarcomata, either resulting from dilatation of ducts or from fatty or mucoid degeneration. Calcareous, bony, or cartilaginous formations have been noted, and are to be considered as curiosities.

The only treatment offering prospect of cure is extirpation, free and complete, so as to remove not only the tumor, but the area of infection, already referred to, as well. Failure to succeed in this latter condemns a patient to early recurrence *in situ*. Local recurrent tumors also are to be excised, and immunity from return is thus gained. The removal of one tumor, when the disease is generalized, is useless. The well-known case of S. D. Gross may be recalled with advantage. A single woman was subjected to twenty-two operations in four years; the number of recurrent tumors removed was fifty-one, and varied in size from an almond to a hen's egg. Large portions of the pectoral, and also of the external and in-

ternal intercostal muscles, were cut away. Ten years and nine months after the last operation she was in perfect health.

Melanotic sarcoma is usually very malignant.

Carcinoma is an atypical new formation of epithelioid elements; for the anatomy, the reader will consult the article on Tumors.

Carcinoma is the most common, and, at the same time, the most fatal of breast-tumors; it affects all classes and all social conditions. Scirrhus and encephaloid, usually known as hard and soft cancer, are the varieties most often met with, the former in far greater proportion than the latter, however. Forty-eight to forty-nine years is generally accepted as the average age of patients coming under treatment; but it is to be remembered that the tumor will have existed for a certain time already before being seen by a physician, or, what is occasionally met with, but I am glad to say rarely, a patient will have been advised by a physician to pay no attention to the lump, and so a long time may be passed in fancied security. My personal experience leads me to consider forty-eight years too late an average age when carcinoma is first observed, forty-five or forty-six being more exact. The menopause is the period just before or after which carcinoma may be expected to appear; indeed, the period of two years preceding the cessation of menstruation is especially favorable for its development. The earliest age at which I have seen a scirrhous carcinoma is thirty years, in a married woman, the mother of four children; the tumor was stated to have existed one year. Before thirty-five the occurrence of carcinoma is very rare. Traumatism and preceding inflammation are occasionally exciting causes, but not sufficiently often to be considered as exercising a potent influence for evil.

Heredity has been long held up as having causative power, but such predisposition can, at most, be traced to nine or ten per cent. Occasionally the opposite is seen, as in the case of Mme. Z—— and family,[26] in whom sixteen deaths from cancer occurred in seventy years.

While, then, blows, the remains of previous abscess, and hereditary peculiarity may and do exist in a causative relation with carcinoma, yet the degenerative changes in the mamma consequent upon cessation of function is, without doubt, the most powerful influence in the development of carcinoma. Carcinoma begins in one breast; its presence in both should be accepted as indicative of general infection; it is never encapsulated, but is infiltrated into the adjacent structures. Thus, the outline is not so well defined as in sarcoma, and while out-croppings are rounded, the body of the tumor may be in shape irregular; this is especially the case with scirrhus. Soft carcinoma is of rapid growth as compared with the hard variety; it is more vascular, more rounded in form, and gives to the hand a sense of fluctuation; the mammary gland is incorporated with, and not distinguishable from, the neoplasm. Scirrhous carcinoma, on the other hand, is of slower growth, of extremely hard consistence without much elasticity, presents to the examining hand firm but not large irregularities, and is apt to be flattened, as indeed the mamma is flattened; in a late stage only is it to be seen as a projecting tuber elevating the skin. Scirrhus conveys to the hand a sense of weight rather than of bulk. Soft carcinoma may attain great size. As a point of differential diagnosis it is to be noted that scirrhus commences generally within the mamma, which is felt, in an early stage, to surround it on all sides, except toward the thorax, of course. Adhesion to chest-wall contra-indicates an operation, the rule in this respect differing from that for sarcoma, which may sometimes be removed with advantage under such circumstances, if of slow growth. Fixation to skin, as well as to chest, is marked in the scirrhus variety, showing itself by lessened mobility and later by the formation of dimples.

Adhesion to chest is recognized by lessened mobility, and is always preceded by the tumor becoming incorporated with the great pectoral muscle; axillary swelling will also be found at this time if sought for. Retraction of the nipple is an almost constant symptom in scirrhus, and results from incorporation of the large ducts with the tumor. Soft carcinoma and sarcoma do not present this peculiarity; hence its importance from a diagnostic view. A discharge from the nipple would indicate implication of the ducts; it is a rare symptom and has no clinical significance. In adeno-carcinoma a serous discharge from the nipple is common. From the preceding it would be expected that a certain fixation of the nipple, the impossibility of drawing it forward, would be present before retraction took place; this is so, and constitutes a valuable diagnostic sign early in the life of carcinoma (scirrhus). Besides adhesion and dimpling, infection of the skin may be recognized by the appearance of small, firm infiltrations, without elevation of surface or discoloration, in the neighborhood of the original growth. These indurations, which are first recognized by the touch, become harder, elevated, discolored, livid, and then ulcerate; in atrophic carcinoma they may even cicatrize. Their presence is indicative of an extremely large infected territory around the primary growth. I have never seen good results follow operations upon such growths; the resulting wound does not cicatrize, and the skin-edges rapidly become infiltrated with new growth. Much importance has been attributed to the presence of large veins in the skin of a breast as indicating a certain kind of tumor; I cannot admit that this is quite the fact, except in the general way that it is usual to find large vascular channels in the vicinity of a rapidly growing neoplasm. In atrophic carcinoma enlarged veins are very rarely seen, for here the circulation near the surface is not greatly increased. Ulceration in the skin is seen, commencing as a crack or fissure, which widens out and deepens, presenting the appearance of a shallow excavation with indurated edges and base usually ragged, of pale color; the discharge is thin and ill-smelling; partial healing, with a thin, unhealthy scar, sometimes takes place. When softening of the tumor occurs, from one cause or another, and the skin gives way, there results a deep, crater-like pit, with everted edges, hard, irregular base, and profuse discharge. Hard carcinoma pursues the manner of ulcerating first described, soft carcinoma the latter. Fungous protrusion I have not seen follow carcinoma ulceration.

Pain is variable. I have repeatedly seen carcinoma of the breast, with implication of the skin and several glandular enlargements in the axilla, and yet the patient only accidentally discovered that the mamma was involved in any morbid process. Two such cases have come under my notice within the past month: both patients were seen within four days after the discovery of the mammary swellings. The classical, lancinating, darting, shooting pains are exceptional in the incipient stage of the tumor; later, however, they are present; with inflammation and sloughing the pain is great; in atrophic scirrhus, with ulceration long continued, pain is extremely varied. Infection of adjacent lymphatic glands in carcinoma is a question of time; sooner or later it will occur, save in rare instances. The axillary glands are the first involved, then the supraclavicular. Just how soon glandular infection occurs is not known, as the primary growth exists some time before being discovered; it is found to be present, usually, about the time when the skin becomes somewhat adherent to the mammary tumor; but a hard and fast rule cannot be laid down.

The axillary enlargements result from the passage of elements from the original tumor through the lymphatics, and their arrest and growth in the lymph glands, thus reproducing the disease in the armpit, from which, continuing their journey by lymph channels, tumor elements enter the general circulation, and carcinosis results. It will sometimes, though very rarely, be found that general infection occurs without glandular implication to any degree; this is to be explained by direct transmission through veins. Occasionally also slight glandular enlargement will disappear after removal of the original growth; in such a case it is clear that the glands were not carcinomatous, and were probably only irritated; but why this should occur in one case and not in another, we do not yet know. Carcinoma shows a predilection for the liver, lungs, and serous surfaces when it attacks internal organs. Colloid and cystic degenerations are those most often met with

in carcinoma. Inflammation running into abscess is rarely seen except in connection with rapid growth, when also acute sloughing may occur.

The prognosis of carcinoma is extremely grave, if left alone or if operated upon. S. W. Gross[27] gives the average duration of life for patients not operated upon as 27.1 months, and for those who died after they had submitted to an operation, as 39 months; which shows that the operation added a year of life to each patient. He furthermore computes the percentages of recovery at 9.05, a small proportion, but how much better than a certainly fatal issue!

Carcinoma following long-continued ulceration of the nipple, Paget's disease, has already been referred to.

Within the past few years our knowledge of adenoma has undergone a great change. Instead of being often met with it is now believed to be one of the growths most rarely encountered, and the so-called adenoid growths, adenocele, and adeno-cystic tumors are recognized as composed of connective-tissue, containing deformed glandular elements—fibromata.

It is doubtful whether it would be possible to differentiate clinically between fibroma and adenoma, nor indeed does it appear to be necessary, since both belong to the category of benign growths, and are to be subjected to like treatment. Perhaps the most notable fact observed in connection with adenoma, is the extreme frequency with which cysts occur in its substance, a circumstance which is due of course to the presence of ducts which have undergone dilatation.

Transformation or change in a tumor is often met with, and is always to be regarded with suspicion if characterized by rapid growth. It is a fact admitting of no dispute that a tumor of formed connective-tissue may develop into a sarcoma and increase quickly, while an epithelial or glandular formation may also grow fast with carcinomatous degeneration. Under such conditions the treatment should not remain in doubt for a moment.

TREATMENT.—A benign tumor of the breast is removed by freely uncovering it; the incision is to be directed from the nipple outward so as to do as little harm as possible to adjacent ducts, after which the growth is to be freed from attachment. It has been suggested that, to avoid a scar, the following manner of operating be adopted: "Carry an incision as long as necessary around the lower edge of the breast where it joins the thorax, raise the breast, and through the incision indicated remove the growth from the posterior aspect of the gland, arrest hæmorrhage, insert a glass drainage-tube, replace the breast," etc. It is probable that few tumors require such an operative measure; benign growths are usually situated in the upper half of the breast, not beneath it, so that an incision through the skin, and at once down upon the tumor, is more simple. As the mamma is generally covered save in exceptional instances, the presence of a scar may be disregarded.

In operating for a malignant growth, there are to be considered three things: first, removal of the tumor; second, recovery of the patient; third, recurrence of the disease. It has been already said that outside and around a malignant tumor there is an area of tissue already sown with seed which, if not removed, will reproduce the original growth. Any operation which removes the tumor and leaves this infected area, will certainly be followed by speedy recurrence; free and complete extirpation is therefore the first duty of the surgeon. In carcinoma, and perhaps sometimes in sarcoma, the axillary glands are involved; they, if movable and not adhering too closely to surrounding parts, are to be taken away. If they are enlarged and cannot be removed, no operation on the breast is to be undertaken. The incision for the removal of the breast is to be extended into the axilla, and carried along the arm sufficiently far to fully open the armpit. The direction of the cutting for breast-extirpation is a matter of no moment; the necessity of the case will indicate the lines of incision. All skin involved in the tumor is to come away, all skin, fat, and connective-tissue near the tumor is to come away, and the entire gland is to be removed. As carcinoma is a degeneration of an atrophying mamma, no mamma tissue should be left by an operation lest it develop carcinoma, and the same rule applied to a sarcoma will do no injury. If there is a suspicion that the great pectoral muscle is involved, the incisions are to be deepened and everything is to be removed down to the thorax. The axilla being widely open, glands are to be sought for, and, if found, removed. It was formerly my habit to extirpate axillary glands, when carcinomatous, by tearing them out, using fingers or a blunt instrument; I do so no longer, for a far more simple and efficacious method is, having widely opened the axilla, to at once clear with the knife the axillary vein, after which the rest of the axilla gives no trouble whatever. It has been my fortune, more than once, to remove with the knife small glands so near the vein that any tearing would probably have ruptured the wall of the vein. It is proper to open the axilla even if no glands have been discovered prior to operating, since the fingers passed into the wound may recognize glands enlarged by disease, yet too small to be felt through the skin; furthermore, I believe the risk to the patient by so doing is scarcely increased, while the advantage is great. The number of glands sometimes taken away is large. The wound may be so extensive that the edges of the skin are separated more or less widely. This is an affair of no moment; the important matter is, first to remove the tumor, and then heal the wound. It is best for the patient that healing be rapid and without inflammation, and union is to be secured as early as possible; but of course free extirpation of the neoplasm, together with infected skin and other tissue, must be the first thing thought of. The wound should be treated on general principles and healing secured. I have observed that patients whose wounds do badly, from erysipelas or other cause, suffer speedy recurrence; an additional reason for securing early cicatrization. Recovery from amputation of the breast is usually rapid, and the mortality is small.

Recurrence after amputation is frequent, and demands extirpation as in the first instance, unless the secondary growth occur at a spot where complete removal is not possible. By repeated operations I have prolonged life and given comfort for years. Within the past month (June, 1885) I have operated upon a single woman, aged forty-eight, for the third time, removing a small nodule as large as a pea, one-fourth inch in diameter, and also two indurated axillary glands. She was first operated upon in 1878, and for recurrence in 1882. Microscopical examination enabled me to make a positive diagnosis in regard to its carcinomatous nature. An operation should not be undertaken if the primary growth cannot be removed together with involved axillary glands, or where it is apparent that general infection has already taken place. The surgeon, therefore, must not only examine the apparently affected region, but also investigate the integrity of internal organs as well. Extirpation of mammary growths by means other than the knife, *e.g.*, by caustics, scarcely requires mention, so much the best instrument is a knife, if properly guided. Until we can find a caustic which will seek out and destroy the neoplasm, sparing healthy tissue, the knife will hold the first place. It may be expedient, after the knife has been used, perhaps, to apply a caustic in vascular tissue, or when the ribs are suspiciously near the base of a carcinoma; but such instances are exceptions. The knife is less painful than anything else for the removal of tissue, when the patient is coming out from the effects of the anæsthetic. When an operation is inexpedient, the surgeon must direct his efforts to the relief of the local discomfort by proper dressings, and to the amelioration of the general condition by appropriate medication. The condition of the patient is most unhappy, and I have always thought it expedient to allow opium or its alkaloid, morphia, in sufficient quantity to bring about a state of comparative relief. I have observed that in stout people recurrence of an extirpated growth is more rapid than in those of more slender build. *L. McLane Tiffany.*

[1] Journ. Anat. and Phys., July, 1879. [2] Thèse de Paris, 1877.
[3] Virginia Med. Month., vol. i., p. 87. 1874.
[4] Dict. des Sc. Méd., vol. iv. 1813. [5] Idem. [6] Idem.
[7] Med. T. and Gaz., vol. ii., p. 70. 1855.
[8] Jour. Gén. de Méd., p. 57. 1827.

[9] Jour. Anat. and Phys., Nov., 1872.
[10] Thèse de Paris, 1880, p. 63.
[11] Lancet, 1840, vol. ii., p. 637.
[12] Lancet, 1837, vol. i., p. 356.
[13] Wien. Med. Presse, 1883.
[14] Am. Jour. Med. Sc., 1834, xiv., p. 374.
[15] Gaz. Méd. de Paris, 1859, p. 818.
[16] Writ. neu beit zur Chirur., 1841, pp. 42–64.
[17] Annali Univ. di Med., 1857, t. clxii., p. 53.
[18] Bibliot. de Manget, t. iii., liv. ii., p. 252 (from Labarraque, Thèse de Paris, 1875).
[19] Loc. cit.
[20] Loc. cit.
[21] Dub. Quart. J. Med. Sc., 1870, p. 349.
[22] Loc. cit.
[23] Brit. Med. Jour., 1874, 11, 106.
[24] Joly: Thèse de Paris, 1851.
[25] Tr. Edinb. Obst. Soc., 1875, 111, 122.
[26] Broca: Traité des Tumeurs, vol. i., p. 152.
[27] Tumors of the Mammary Gland, p. 164.

BREATH. The expired air, called the breath, is composed of nitrogen and oxygen, the latter in a proportion less than that existing in the atmosphere, and contains a little over four per cent. of carbonic acid, besides aqueous vapor, ammonia, and organic impurities. The proportion of carbonic acid is increased in the early stages of small-pox, measles, and scarlatina, diminished in typhus fever, and increased during the existence of any extensive skin disease. The temperature varies somewhat, being influenced slightly by that of the external air, but seldom falls below 90° F. When the temperature of the inspired air is very high, as in the hot room of a Turkish bath, the breath may appear, by comparison, to be cool. In fevers its heat is increased, but in the algid stage of cholera it is almost cold.

In health the breath is nearly odorless, but it is modified in this respect by often very slight causes, and in certain morbid conditions the odor is quite characteristic and may be valuable as a diagnostic sign. Thus, in diabetes mellitus, there is often a peculiar sweetish odor which is difficult to describe, and has been likened to that of honey, sweet apples, or hay. In pyæmia, also, the breath is peculiar and characteristic. In chronic alcoholism the odor of the expired air is very foul, not necessarily alcoholic unless liquor has been recently taken, but possessing a peculiarity all its own, and unlike anything else. Dr. Tavignot, a French writer, described, some years ago, a peculiarity of the breath in glaucoma, to which he gave the name of *haleine safranée*, and he maintained that this was constantly present in persons suffering from that affection. Many volatile substances taken into the system through the ordinary channels are excreted in part through the lungs, and impart their odor to the breath. Thus turpentine, alcohol, onions, and many other alimentary and medicinal substances, taken into the stomach, are quickly detected by their peculiar smell in the expired air.

A permanent foulness of the breath is due either to local causes existing in some part of the respiratory tract, or to interference with the elimination of the products of decomposition by the intestines and kidneys. Among the local causes we have to consider various affections of the mouth, nose, pharynx, larynx, and lungs.

Dental caries is a well-known cause of foul breath. This arises not only in consequence of the decay of the teeth, but also, and chiefly, from decomposition of particles of food lodged in the cavities and between the teeth. The latter may give occasion to a fetid breath in persons who are careless in cleansing the mouth, even when the teeth are perfectly sound. In necrosis of the jaw the odor is frequently sickening, as it is also in follicular tonsillitis and pharyngitis. In the latter case the odor is due to decomposition of the secretion and food particles filling up the follicles, and is often suggestive of fæcal matters. In diphtheria, also, there may be a disagreeable fœtor of the expired air suggestive of putrefaction. There is a condition known as catarrh of the tongue, which is usually associated with dyspepsia, but may occur independently of it. Here again decomposition of mucus, epithelial scales, and food particles is the offending cause. Gingivitis, from arsenical or mercurial poisoning or from scurvy, may give rise to a bad breath, as may also syphilitic ulcerations of the buccal cavity or fauces. Ozæna, from whatever cause produced, is frequently responsible for a most foul and repulsive odor. Syphilitic and tubercular ulcerations in the larynx often impart an unpleasant odor of the breath, and the fœtor of some forms of bronchitis, of bronchiectasis, and of abscess and gangrene of the lungs, is too well known to require any description.

Perhaps the most frequent cause of a bad breath is dyspepsia, either gastric or intestinal. In this case the elimination of the products of decomposition and of the effete matters of the tissues by the normal channels is interfered with to a greater or less extent, and the task of their excretion from the economy is in part thrown upon the lungs. The expired air contains a large amount of organic matter which is often very ill-smelling and offensive. It is in chronic constipation, especially, that this odor of decomposing organic matter is most marked. In uræmia the breath is said to often acquire a strongly ammoniacal odor, due to the non-elimination of the urea.

The odor of the breath is modified temporarily by many causes. As stated above, various substances, when taken into the stomach, impart their characteristic odor to the breath. In women the expired air frequently acquires a disagreeable character during the menstrual period, and a fetid breath is often excited by fits of anger or other strong emotions. In feverish conditions the breath acquires a sweetish, or sometimes sickening, character. This is particularly noticeable in children, and in them is often suggestive of the odor of chloroform.

Various mineral substances, which are themselves nearly or quite without smell, cause, when introduced into the system in sufficient quantities, and during a certain period of time, a very disagreeable odor of the breath. This occurs from stomatitis in some cases, and in others from the disturbance of digestion, induced by the chronic poisoning. The substances which most frequently are concerned in the production of toxic halitosis are: antimony, arsenic, lead, mercury, phosphorus, and sulphur.

Finally, some individuals suffer from a more or less fetid breath, the cause of which is impossible to discover. It is constant, and not dependent upon any apparent deviation from health, but is often associated with a strong and unpleasant odor of the sweat and other secretions.

In the following table these various conditions leading to the production of a bad breath are arranged under their several classes for convenience of reference:

CAUSES OF HALITOSIS.

Transient	Mental disturbance.		
	Various ingesta, medicinal and alimentary.		
	The menstrual period.		
Systemic	Fevers.		
	Diabetes mellitus.		
	Uræmia.		
	Pyæmia.		
	Glaucoma (?).		
Toxic	Antimony.		
	Arsenic.		
	Lead.		
	Mercury.		
	Phosphorus.		
	Sulphur.		
	Alcohol.		
Digestive	Gastritis.		
	Dyspepsia.		
	Cancer of stomach or liver.		
	Constipation.		
	Hepatic disorders.		
	Enteritis.		
	Intestinal worms, particularly ascarides in children		
Buccal	Dental caries.		
	Gingivitis. Stomatitis.	Toxic.	
		Scorbutic.	
		Syphilitic.	
	Lingual catarrh.		
	Necrosis of jaw.		
	Carcinoma of tongue and other parts.		
	Cancrum oris.		
	Lack of cleanliness.		
Nasal	Polypi.		
	Ozæna.	Herpetic.	
		Syphilitic.	
		Idiopathic.	
		Osteo-necrotic.	
Faucial	Follicular tonsillitis.		
	Follicular pharyngitis.		
	Syphilitic ulceration.		
	Diphtheria.		
	Putrid sore throat.		
Laryngeal	Carcinoma.		
	Ulceration.	Syphilitic.	
		Tubercular.	

Pulmonary .... { Bronchiectasis. Putrid bronchitis. Tubercular ulceration (cavities). Gangrene. Abscess. Carcinoma. }

Idiopathic.

The treatment of a foul breath consists essentially in discovering, and, if possible, removing the cause. In by far the largest number of cases the origin of the trouble resides in digestive disturbances, usually associated with constipation, or in carious or dirty teeth. The first care of the physician should be, therefore, to regulate the digestive functions, and to see that the hygiene of the mouth is properly attended to. If the gums are spongy or receding, a tooth-wash containing myrrh should be used. All cavities should be plugged with gold or some other suitable filling, as the dentist may advise, and the tartar, which accumulates between and behind the teeth, should be removed from time to time. The teeth should be picked, after each meal, to remove the particles of food, and should then be brushed with plain water, soap and water, or a reliable dentifrice. If the stomach is at fault, in addition to the remedies suitable to the condition, a piece of charcoal cake or charcoal powders may be taken shortly after meals. An odor which cannot be removed may be more or less effectually disguised by oil of nutmeg, cinnamon, cardamom seeds, cloves, pimenta or allspice, coffee, and other aromatics. A solution of carbolic acid (1 to 200) may be used as a mouth-wash or gargle when the fœtor is due to organic destruction of tissue. The following is an agreeable mouth-wash which will often disguise unpleasant odors: Thymol, 0.50 gm. (7½ grains); borax, 1 gm. (15 grains); distilled water, 500 gm. (1 pint). The mouth is to be rinsed frequently with this solution. All these deodorizers are, however, of necessity merely palliative in their effects, and the cause should always, if possible, be searched for and removed.

Thomas L. Stedman.

BRIGHTON, ENGLAND. Brighton is one of the most fashionable sea-side resorts of England, fifty miles from London, on the south coast of Sussex, in lat. 50° 50′ N., and long. 0° 8′ W. Including Kemptown, Brighton extends three miles along the coast, fronted by a high sea-wall that forms a magnificent drive and promenade, and occupies a central valley and slopes on the east and west. In the central part the town extends a mile inland. Fine hotels, pleasant walks, places of amusement, and good baths are among the advantages of Brighton, and the air is free from the smoke of manufactories. But it has the drawback of being a large city, and there is naturally much animal and vegetable miasm, which is especially apt to cling to the beautiful promenade on the shore when there is a weak land breeze.

The subsoil is chalk in the east, chalk covered with a layer of shingle in the valley, and clay in the western part of the town. The drainage is, however, considered to be good, and in the country about the town the subsoil is gravelly and there are no stagnant waters.

The atmosphere is bracing, particularly in the east, but in the valley it differs little from that of an inland town. In the height of the season, from October to December, it is dryer, warmer, and less cloudy than inland places, and is appropriate for chest diseases that require some protection, particularly by reason of the promenade on the east side being wholly protected from the north wind.

The changes of temperature in Brighton are often very rapid, sometimes as much as 10° or 15° F. in a few hours. Besides this, there are considerable differences of temperature at the same time in various parts of the city. The average temperature is given as follows by Hann ("Handb. der Klimatologie"): January, 39.4° F.; April, 49.8° F.; July, 62.9° F.; October, 52.3° F.; and for the year, 50.7° F. In general, however, Brighton is warm and dry, and as such particularly suitable in convalescence from Bright's disease in the acute form, and in all chronic forms. It is of service, also, in diseased conditions where there is loss of appetite and anæmia, and in some cases of asthma.

W. G. Le Boutillier.

BROMAL HYDRATE, $C_2HBr_3O.\ 2H_2O$. Like chloral, *bromal* is an oily fluid which, uniting with water, forms a crystalline hydrate. Bromal hydrate occurs in white crystalline masses of a sharp, burning odor and taste, fusible at 53.5° C. (128.3° F.), and soluble in water. Physiologically the drug is severely irritant, and, absorbed into the circulation, has been found by experiment (Steinauer) to cause restlessness followed by sleep, and, if dosage be pushed, dyspnœa, convulsions, and death. It may relieve pain, and has been thought to be of avail in averting threatened epileptic fits, but it is not officinal in the U. S. Pharmacopœia and is little used in medicine. It has been given in three-grain doses (Steinauer), but it is so disturbing to the digestive functions that the dose must be given in great dilution.

Edward Curtis.

BROMIDES. 1. General Medicinal Properties of the Bromides.— Compounds of bromine, whose basylous radicle is innocuous enough to permit of their medicinal administration in decided quantity, all show a certain influence over the animal system, commonly, and undoubtedly rightly, referred to the action of the bromine of their composition. Of the effects, the most striking feature is derangement of nerve-function, which, in moderate dosage, takes the form of a deadening of reflex irritability, cerebral and spinal, and in poisonous administration shows itself as failure of power, voluntary as well as reflex, in the cerebro-spinal centres. Clinically, the prominent effects are that the nervous, agitated, and wakeful subject becomes calm, tranquil, and predisposed to sleep; that convulsive seizures, the expressions of unnatural reflex irritability, such as the convulsions of epilepsy and of tetanus, tend to abate in frequency and violence; that a qualmish stomach becomes quieted, that tickling of the fauces fails to provoke gagging, and that sexual eagerness and even power wane. In profounder bromism what was at first intellectual laziness and indifference becomes positive stupidity, with failure of memory and with or without a certain grade of aphasia; what was a dulness of reflex activity passes to motor and sensory weakness—paresis of sight, hearing, and tactile sense and profound muscular debility, until at last, after apparently total abolishment of all conscious existence, the poisoned subject dies, either from respiratory or cardiac failure. Minor effects are, when a bromide is continuously taken, a peculiar fœtor to the breath, a tendency to an acneform eruption, most pronounced on the face, arms, back, and buttocks, and a tendency to congestion and even œdema of the fauces and uvula, and, later, of the conjunctiva also. All of these various symptoms, formidable though many of them are, rapidly abate upon discontinuance of the medicine, and, as a rule, leave no permanent morbid results. Other effects, notably derangement of the circulation and lowering of body-temperature, are observed in the operation of the most commonly used bromide, namely, the potassic, and also in that of the closely allied lithic bromide; but inasmuch as these are effects which are more or less common to all salts of potassium and lithium, it is an open question whether their occurrence in the present connection is not rather due to the basylous element of the bromide than to the bromine. Bromides are quick of absorption, and, generally speaking, fairly quick of elimination, and in such elimination are to be found in all the secretions—urine, fæces, sweat, saliva, and even in the pus of the acne-pustules.

The most interesting effect of bromides, namely, the derangement of function of the cerebro-spinal nervous system, has been made the theme of much experimentation for the purpose of finding just where the bromide influence strikes. As usual, the experiments are not wholly in accord, but their general drift clearly indicates, as H. C. Wood points out, that the peripheral ends of the afferent nerves and those portions of the axis that have to do with the reception of sensory impressions and their transmission as an impetus for motor reflex response, suffer first and most severely in deadening of functional activity, while later, and to a proportionately lesser degree, are affected the motor tract of the cord and the

motor nerves. By this hypothesis is rendered intelligible the oft-observed occurrence that a bromized frog, while profoundly indifferent to pricks or searings, from evident cutaneous anæsthesia, may still retain enough command of motor power to hop, and vigorously too, at will.

The *therapeutics* of the bromides consist of the direct application, for clinical ends, of the bromine influence to blunt nervous impressibility. Such displays, therefore, of so-called nervous excitement as are the expressions of a state of direct morbid irritation of the nervous system, in whole or in part, are conditions proper for the action of a bromide; but, on the other hand, the derangements of nerve function caused by *exhaustion*, general or local, are distinctly *not* to be treated by bromine medication. For in such latter case, because of the generally depressing character of the bromine influence, the exhaustion will be deepened, and the nervous symptoms, therefore, intensified. Prominent illustrations of the conditions where bromides may be of benefit are undue restlessness and wakefulness, or mental irritability or morbidness from any emotional cause, or from severe intellectual labor under pressure; undue excitability of a lusty sexual apparatus from too free indulgence; and, more notable still, expressions of reflex action, such as the convulsions of epilepsy, of tetanus, or of strychnine poisoning; the convulsions of children, so easily induced, in many, by a variety of causes; seasickness or the vomiting of pregnancy or of neurotic poisoning. Conditions where, on the other hand, bromides are useless or harmful, are restlessness, wakefulness, or mental derangement from want of sleep, from starvation, from loss of blood, or devitalization from a prostrating disease, such as typhoid fever, or, locally, irritability of the sexual organs when associated with beginning of failure of power through exhaustion from excessive abuse. In cases for which bromides are fitting it is hardly necessary to say that the remedy will promise more if resorted to at the outset, and that large doses may conquer where small ones will utterly fail. In chronic and intractable disease, such as epilepsy, two points, beside sufficiency of dosage, must be observed, namely: *first*, that the blood must be kept evenly and continuously charged with the bromide salt, a result which, considering the comparatively rapid elimination of the salt, can only be secured by giving the daily allowance in at least three doses, whereof the evening one, having longer to last, should be larger than the others; and, *secondly*, that the medication must not be too speedily discontinued after apparent cure of the malady, but, on the contrary, must be kept up for months, and even years, thereafter. In epilepsy, it is singular that the form of the disease called *petit mal* should be, as it is, distinctly less amenable to bromide medication than the classical form where the fits are outspoken. In epilepsy, when the disease is recent and of the latter variety, the curative power of the bromides surpasses that of any other drug, but the remedy will commonly have to be pushed to the development of a certain grade of bromism before benefit appears. In tetanus, also, the results of bromine medication fully equal those of any other treatment, and a bromide in conjunction with chloral hydrate is, at present writing, probably the remedy in most repute.

2. THE MEDICINALLY USED BROMIDES.—The bromides officinal in the U. S. Pharmacopœia are, among bases of the heavy metals, *zincic* bromide, and among those of the alkali metals and metals of the earth, *potassic, sodic, lithic, ammonic,* and *calcic* bromides. *Hydrobromic acid* and *brominated camphor* may also be mentioned as being, logically, bromides, and as furthermore showing in their action upon the animal system the peculiar bromine influence in addition to their other effects. Lastly, an ethereal bromide, namely, *monobromethane* ("bromide of ethyl," "hydrobromic ether"), although not officinal, has been used in medicine as an anæsthetic. In the present article will be discussed only the bromides of the metals of the alkalies and earths, in which alone the bromine influence is the dominant medicinal virtue. For *bromide of zinc*, see Zinc; for *hydrobromic acid*, see Hydrobromic Acid; for *brominated camphor*, see Camphor; and for *bromide of ethyl*, see Ethylic Bromide.

Potassic Bromide: KBr. Potassic bromide is officinal in the U. S. Pharmacopœia as *Potassii Bromidum*, Bromide of Potassium. It occurs in "colorless, translucent, cubical crystals, permanent in dry air, odorless, having a pungent, saline taste, and a neutral reaction. Soluble in 1.6 part of water and in 200 parts of alcohol at 15° C. (59° F.); in 1 part of boiling water, and in 16 parts of boiling alcohol. The commercial salt generally appears in white, opaque, or semitransparent crystals, having a faintly alkaline reaction; but single crystals laid upon moistened red litmus-paper should not at once produce a violet-blue stain (absence of more than about 0.1 per cent. of alkali). At a dull red heat the salt melts without losing weight. At a full red heat it is slowly volatilized without decomposition" (U. S. Ph.). In some commercial samples the alkalinity is said to be decided, sufficiently so to enable the salt to precipitate alkaloids from solutions of their salts.[1] Potassic bromide should be kept in well-stopped bottles.

Potassic bromide is the most generally active, the best known, and the most commonly prescribed bromide. It is capable of producing, to the highest degree, the peculiar bromine effects already detailed, and also has a marked influence over the circulatory organs, and, if pushed to poisoning, a power to distinctly lower body-temperature. The circulatory derangement consists in, first, a slowing and weakening of the heart's contractions, passing even to stoppage of the organ in diastole; and, secondly, a probable—but probable only—narrowing of the lumen of the smaller blood-vessels, through vaso-motor spasm. Partly because of the certain effect upon the heart, and partly also because of the possibly rightly assumed effect upon the blood-vessels, potassic bromide is commonly held to induce partial capillary anæmia, especially of the nerve-centres—spinal cord and brain. And because of this anæmia, in turn, it has been imagined by some, and become quite a text-book tradition with many, that the action upon the vascular organs is the only direct one that potassic bromide exerts, all the nervous phenomena being sweepingly accounted for as mere secondary consequences of a diminished blood-supply to the cerebro-spinal axis. To refute this notion, it seems only necessary to cite, on the one hand, the fact that other bromides than the potassic, which have but little of the depressing effect of the latter salt upon circulation, yet show the bromine influence over nerve-function, and, on the other hand, to note that cerebro-spinal anæmia, occurring as it can easily be made to do, experimentally, by other methods and to any degree, is, when so determined, never followed by the peculiar phenomena of bromism.

As the drug is medicinally given, the clinical effects of potassic bromide are a salty taste in the mouth, with a little increase in the flow of the saliva, and perhaps also some diuresis; an abatement of all forms of nervousness, fidgets, or even spasms, with a tendency to mental calm and indifference, intellectual and physical sloth, and, if circumstances favor, drowsiness. Along with these suggestive symptoms the pulse falls somewhat in force and frequency. If the dose have been single and not over large, little other than the foregoing effects will be declared; but, if the taking be continuous and the doses range high, the derangement may be profound, the subject presenting the picture of one mentally dull even to idiocy, with perhaps some aphasia; dull of hearing, sight, and feeling; physically weak even to paresis, sexually impotent, and with the peculiar symptoms of a fœtid breath, a whispering voice, a face broken out in acne, a congested or even œdematous faucial arch, a slow and failing pulse and respiration, and a depressed body-temperature. In overwhelming dosage, paralysis of sense and motion becomes absolute, and death ensues quietly by failure of respiration or of cardiac action—the former if the poisoning have been progressive by accumulating small doses, the latter if by a single overpowering charge. But, as usual with the bromides, so long as the condition is one short of death, the symptoms will quite certainly ameliorate—and that, too, without lasting results—upon discontinuance of the administration. In case of serious poisoning, the treatment must be in accordance with gen-

eral principles only, consisting in evacuation of the stomach, if a large single dose have been taken, and, for the rest, the employment of measures addressed to maintaining the action of the heart and lungs.

Potassic bromide is used, medicinally, exclusively for the peculiar purposes of the bromides generally, as set forth in the first section of this article. Where the need is transient only, as to quiet a squeamish stomach, or to calm a restless subject and invite sleep, the dose will range from 1.30 to 3.00 Gm., or thereabouts (twenty to forty-five grains), according to the intensity of the disturbance and the susceptibility of the individual. Where, on the other hand, a continuous and powerful impression is necessary, as in treating epilepsy or tetanus, the doses may have to be both large and frequent. In dealing with epilepsy, the daily quantity will rarely be less than 6.00 Gm. (ninety grains), and may need to reach 15.00 Gm. (half an ounce), given broken up into three or four doses evenly distributed over the waking hours, excepting as to the evening portion, which should be somewhat larger than the others. The actual dosage in a given case must be determined by the effects produced upon the fits. A clinical rule with some is to give the salt until the usual reflex gagging, occurring upon tickling the fauces, is found to have become abolished. Even with the smallest daily quantity above named, a certain degree of "bromism" will follow the continuous giving, and such must be expected. Rarely, indeed, will any impression be made upon the epilepsy until some bromism does show itself. In tetanus or strychnine poisoning the dosage of bromide reaches its maximum, the extraordinarily heightened reflex irritability, which is the essence of the morbid condition in the two affections, making the subject comparatively insusceptible to the benumbing influence of bromine. Doses of 15.00 Gm. (half an ounce), even, have been given at a single draught, and the daily total should certainly reach this figure. Yet in strychnine poisoning it must be remembered that the tetanus, if it does not kill within a couple of hours, then rapidly abates, and simultaneously, of course, disappears the insusceptibility to bromide influence. Care must therefore be taken to diminish the bromide dosing, as the morbid irritability fades, else, as has actually happened, the subject may be saved from death by strychnine convulsions only to be brought to the verge of the grave by bromide palsy. Potassic bromide is administered in solution, either in simple iced water, or, what is pleasanter, and in case of large doses makes the draught less obnoxious to the stomach, in water slightly alkalized by the addition of a little sodic bicarbonate; or, best of all, in water both alkaline and effervescent, as Vichy [2] or Apollinaris.

Sodic Bromide: NaBr. The salt is officinal in the U. S. Pharmacopœia, as *Sodii Bromidum*, Bromide of Sodium. It occurs in "small, colorless or white, monoclinic crystals, or a crystalline powder, permanent in dry air, odorless, having a saline, slightly bitter taste, and a neutral or faintly alkaline reaction. Soluble in 1.2 part of water, and in thirteen parts of alcohol at 15° C. (59° F.); in 0.5 part of boiling water, and in eleven parts of boiling alcohol. When heated to a dull red heat, the salt melts without losing weight. At a full red heat, it is slowly volatilized without decomposition. A fragment of the salt imparts to a non-luminous flame an intense yellow color, not appearing more than transiently red when observed through a blue glass" (U. S. Ph.). Sodic bromide is hygroscopic, and should be kept in well-stopped bottles.

Sodic bromide is less unpleasant to taste than the potassic salt, and is in every way less deranging of function. But yet, despite the fact that its innocuousness permits of its prescription in larger doses and for more continuous administration than is always possible with potassic bromide, the bulk of testimony goes to show that the sodic salt is of distinctly inferior curative power. Its use is, therefore, properly confined either to cases where but a mild effect is called for, or to those where, for any reason, the potassic salt cannot be given, or having been given must be abandoned. The fact that weight for weight, sodic bromide contains more bromine than potassic (in the proportion of 77.62 to 67.13), simply shows the more forcibly the intrinsic physiological feebleness of the compound. Sodic bromide should be given in he same manner as the potassic salt, and may be begun with in the same dose, to be carefully augmented according to the effects produced.

Lithic Bromide: LiBr. The salt is officinal in the U. S. Pharmacopœia as *Lithii Bromidum*, Bromide of Lithium. It occurs as a "white, granular salt, very deliquescent, odorless, having a very sharp, somewhat bitter taste, and a neutral reaction. Very soluble in water and alcohol. At a low red heat the salt fuses, and at a higher heat it is slowly volatilized. A fragment of the salt imparts a crimson color to a non-luminous flame" (U. S. Ph.). Being exceedingly deliquescent, this salt should be kept in well-stopped bottles.

So far as observed, lithic bromide very closely resembles the potassic salt in its effects, as the nature of its base would render likely. Dr. S. Weir Mitchell, of Philadelphia, who first advocated this bromide for use in the nerve affections for which potassic bromide is commonly prescribed, considers the lithic salt more speedily and more powerfully hypnotic than the potassic. It has the demerit of comparative costliness. It contains, proportionally, more bromine than does any other of the alkaline bromides, and has been advised to be given in one-half the dose of the potassic salt (Weir Mitchell).

Ammonic Bromide: NH_4Br. The salt is officinal in the U. S. Pharmacopœia as *Ammonii Bromidum*, Bromide of Ammonium. It occurs as "colorless, transparent, prismatic crystals, or a white, granular salt, becoming yellow on long exposure to air, odorless, having a pungent, saline taste, and a neutral reaction. Soluble in 1.5 part of water, and in 150 parts of alcohol at 15° C. (59° F.); in 0.7 part of boiling water and in 15 parts of boiling alcohol. Upon ignition the salt volatilizes completely without melting" (U. S. Ph.).

From the point of view of the clinician, ammonic bromide may be regarded as substantially a duplicate of potassic bromide in medicinal virtues, while, at the same time, more acrid in taste and in local action. It has been used for the same purposes as the potassic salt, and in the same dose, but though strongly recommended by Brown-Séquard and others in epilepsy, it has not made itself generally believed to be any better than potassic bromide.

Calcic Bromide: $CaBr_2$. The salt is officinal in the U. S. Pharmacopœia as *Calcii Bromidum*, Bromide of Calcium. It is a "white, granular salt, very deliquescent, odorless, having a pungent, saline, and bitter taste, and a neutral reaction. Soluble in 0.7 part of water, and in 1 part of alcohol at 15° C. (59° F.); very soluble in boiling water and in boiling alcohol. At a dull red heat the salt fuses without losing anything but moisture. At a higher temperature it is partly decomposed" (U. S. Ph.). The salt must be kept in well-stopped bottles.

Like the ammonic salt, calcic bromide does not seem to differ materially in properties from potassic, and stands in medicine as an additional and not over-necessary substitute for the same, in the same range of application and in the same dosage. It was originally proposed by Dr. W. A. Hammond, of New York, in 1871.

Edward Curtis.

[1] U. S. Dispensatory, 15th ed., quoting Chas. D. Chase.
[2] Seguin: Archives of Medicine.

BROMIDROSIS. Bromidrosis is a functional disorder of the sweat-glands, characterized by more or less sweating and an offensive odor. It may be general or local. When universal the patient exhales a heavy, disagreeable odor, which at times has a distinctive character, as of a goat, of urine, onions, assafœtida, sulphur, or musk. The odor of the body may in some cases be connected with some systemic disease, as measles, small-pox, etc., or it may be due to medicines taken or to certain forms of diet. In the generalized form of bromidrosis the odor is not necessarily connected with sensible perspiration.

The local form of bromidrosis is that usually encountered, it is, in fact, a form of Hyperidrosis (*q. v.*). The

axillæ, genitalia, perineum, and feet are the usual seats of the disorder. The odor is sometimes slight, at other times so offensive as to exclude the sufferer from all society.

In the feet the odor proceeds from the stockings and shoes, and treatment must include some means of keeping these pure. Thin recommends cork insoles soaked in boracic acid, and also that the stockings should be soaked in the same and dried before using. Local medication is most important. The remedies mentioned under Hyperidrosis are, of course, useful, and in addition solutions of permanganate of potassium, from one to three grains to the ounce; of boracic acid, saturated; or of chloral, ten to forty grains to the ounce, are of use. Among powders, salicylic acid with starch is perhaps the best. The treatment for general bromidrosis must be based on an examination of the patient's general condition, and directed to obviate any defect which may be observed.

Arthur Van Harlingen.

BROMINE. Bromine is officinal in the U. S. Pharmacopœia, as *Bromum*, Bromine. It is described as "a dark, brownish-red, mobile liquid, evolving, even at the ordinary temperature, a yellowish-red vapor highly irritating to the eyes and lungs, and having a peculiar, suffocating odor, resembling that of chlorine. It boils at 63° C. (145.4° F.), and has the sp. gr. 2.990. It is soluble in 33 parts of water at 15° C. (59° F.), and is dissipated on boiling the water, and is very soluble in alcohol and in ether with gradual decomposition of these two liquids; also very soluble in chloroform and in disulphide of carbon. It is completely volatilized by exposure to air or to heat. It destroys the color of litmus and of sulphate of indigo, and renders gelatinized starch yellow" (U. S. Ph.). Bromine has the same intense affinity for hydrogen that chlorine has, and so, in similar manner to chlorine, determines the oxidation of organic matter in the presence of moisture by appropriating the hydrogen of the water and liberating the oxygen. The fumes of bromine are thus deodorant, like chlorine, and if present in an atmosphere in great volume would doubtless prove disinfectant to floating disease-germs. Mixed directly with foul-smelling or infectious matter, bromine is powerfully deodorant and disinfectant. But while there is thus no deficiency of power, yet bromine is but little used for the purposes just suggested, for the several reasons of its expensiveness, abominable smell, caustic and bleaching tendency, and the exceedingly irritant action of its vapor upon the human air-passages. Squibb estimates that an ounce of bromine, accidentally spilled in an ordinary chamber, would render the air thereof dangerous to life.

Locally applied to living animal tissues, pure bromine is a very searching and painful caustic, and non-caustic dilutions act as detergent and stimulant lotions to foul or sloughing ulcers. Here again, however, the cost of the remedy and its offensiveness render it less practicable than its efficiency would suggest. For caustic purposes, bromine is applied clear, the patient, if the area to be cauterized is at all extensive, being etherized, and the operator taking care that his eyes and nose do not come too near the fumes of the very volatile and pungent liquid. As a strong lotion, a ten per cent. solution in water may be employed, the solution of the bromine being effected by adding one-third its weight of potassic bromide to the mixture. For weaker lotions—any percentage less than three—bromine is directly soluble in water without any saline addition. Taken internally, bromine is doubtless absorbed as a bromide. It was formerly used as an internal medicine in the class of diseases for which iodine or the alkaline iodides are now so extensively employed. For the specific purposes of the alkaline bromides (see Bromides), bromine is practically unavailable, because of the inevitably irritating effect, to say nothing of the disagreeableness of the draught, of the large dose that would be required. Bromine has been given internally in the dose of from three to six drops of a two and a half per cent. aqueous solution.

Edward Curtis.

BROMINE CHLORIDE. By direct union of the two elements, bromine and chlorine, a compound is formed, appearing as a reddish-yellow, volatile, mobile fluid, soluble in water. This compound is powerfully caustic, but has never been used in regular medicine except as an ingredient of a caustic paste used by Landolfi, of Naples, for the treatment of cancer. *Edward Curtis.*

BROMOFORM. Bromoform, or *tribromomethane*, $CHBr_3$, is a heavy, colorless liquid, volatile, of a sharp ethereal odor and rather sweetish taste. It dissolves sparingly in cold water, but readily in warm water and in ether; specific gravity, 2.9; boiling-point, 151° C. (303.8° F.) (Horoch). Bromoform has recently been experimented with as a possible anæsthetic by von Horoch, of Vienna. Administered to cats and rabbits by inhalation, by the mouth and by hypodermatic injection, the agent produced narcosis easily developed and with a short initial stage of excitement. During the narcosis the body-temperature sank, and reflex irritability entirely disappeared, while yet the heart-action remained good and the respiration was but little affected. Recovery took place without vomiting. The narcosis, especially when established by hypodermatic injection, was profound and prolonged. In three cases bromoform was given by inhalation to men with the production of effects similar to those obtained upon animals. A disagreeable feature of the anæsthetic was irritation of the mucous membrane of the air-passages and of the conjunctiva. *Edward Curtis.*

BRONCHI, MINUTE ANATOMY OF. As a preface to the histology of the bronchi, a short *résumé* of the gross anatomy seems here desirable. The bronchi—more properly bronchia, βρογχια, meaning swallow or throat—probably received the name through Plato, who taught that their function was to receive the liquids, the œsophagus receiving the solids. Aristotle having supported this theory, the name remained so long in medical use as to become a fixture.

The bronchia, beginning at the tracheal bifurcation opposite the third dorsal vertebra (fourth in female), terminate in the pulmonary lobules. The primary tracheal branches, from their distribution, are named the right and left bronchus. The former is shorter, larger, and more horizontal than the latter, and the septum bronchiale separating them is placed to the left of the longitudinal (in the recumbent posture of the body) axis of the trachea. Hence, bodies falling into the trachea lodge more frequently in the right bronchus. Hyrtl teaches that post-mortem examinations of the new-born, dying after a few respirations, show that the right lung respires before the left, and he explains the fact by the difference in size and location of the beginning of the right bronchus. The general rule of dichotomous subdivision obtains, but is not without exception; *e.g.*, the right bronchus subdividing into three branches, one for each lobe. Occasional small branches are given off by the main trunk. Having reached the diameter of 0.21 mm. ($\frac{1}{120}$ inch), they enter the apices of the pulmonary lobules. Here again branching at acute angles they dilate slightly, becoming funnel-shaped, whence the name "infundibula vesicæ" (see art. Lungs, Minute Anatomy of).

STRUCTURE.—The bronchia are hollow cylindrical tubes, which retain in structure, through a large portion of their extent, the characteristics of the trachea. Like the latter, they consist of four distinct layers, an external fibrous, a muscular, an internal elastic, and a mucous layer.

The external fibrous layer consists of a dense meshwork of connective-tissue, in which are to be found rings or laminæ of hyaline cartilage. In the primary bronchia these are disposed as in the trachea, *i.e.*, in broken rings like the letter **C**, held together by fibrous bands. The ring is made complete by small transverse bundles of unstriped muscular fibres attached by microscopic tendons to the ends of the rings. By their contraction they increase the curvature of the cartilage and so diminish the calibre of the tube. The right bronchus contains six to eight of these cartilages; the left ten to twelve. Further

removed from the trachea the cartilages gradually lose their ring-like shape, and are disposed in irregular polygonal laminæ. Becoming smaller and less frequent, they finally disappear in tubes of less diameter than 0.23 mm. ($\frac{1}{100}$ inch), the fibrous layer still continuing to form the external coat.

The muscular layer lies within the fibrous layer just described. It consists of separate bundles of unstriped muscular fibres, disposed for the most part transversely to the tube. It is better developed in the intervals between the cartilages than just beneath them. As the cartilages disappear this muscular layer becomes better and better developed, so that it completely surrounds the bronchioles, which, on section, but for the epithelial lining, might be mistaken for arterioles. The muscular layer can be traced to the final branching of the bronchiole to form the alveolar passages, where, according to Rindfleisch, it becomes again better developed into a sort of "sphincter" at the point of entrance to the alveolar passages. The function of the muscular layer is to narrow the calibre of the tubes. This is only manifested to any appreciable extent in the bronchioles. The cartilages prevent any decided narrowing where they exist. In the experiments of Dr. C. J. B. Williams with electrical stimulation on bronchioles of less than a line in diameter,

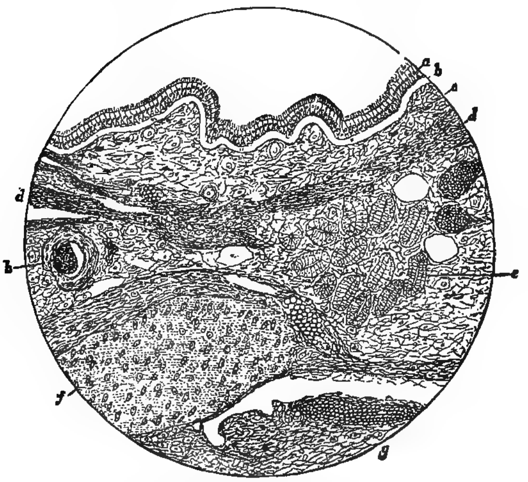

FIG. 525.—(Drawn with camera by Dr. F. Cary.) Represents a Transverse Section of the Bronchial Wall at the Fifth Bifurcation in the Human Adult. *a*, Epithelial layer of mucous membrane; *b*, hyaline basement membrane, formed from *c*, internal elastic layer, showing its varying thickness; *d d*, muscular layer; *e*, muciparous crypts; *f*, cartilaginous lamina; *g*, external layer; *h*, branch of bronchial artery. (About 30 diameters.)

they were seen to contract until nearly obliterating their lumen. Dr. Gairdner suggested that the contractility of the minute bronchioles may serve to expel collections of mucus which have accumulated in them, that neither ciliary action nor the ordinary expiratory efforts would dislodge.

The Internal Elastic Layer.—Within the muscular layer, and beneath the mucous membrane, lie longitudinal bundles of elastic tissue tolerably regularly disposed. They project, as it were, partly into the lumen of the tube, and so give, on transverse section, a wavy, corrugated appearance to the lining membrane; on longitudinal section, a grooved or furrowed one. Piercing this as well as the muscular layer, chiefly in the bronchial tubes containing cartilages, are to be seen the muciparous ducts, lined with epithelium, leading inward to open on the free surface of the mucous membrane. The mucous crypts lie in the external fibrous layer, chiefly in the intervals between the cartilages.

The mucous membrane of the bronchia and bronchioles, forming the internal layer, possesses, throughout the great portion of its extent, the characteristics of that of the tracheal mucous membrane. Like the latter, it consists of epithelial cells of the ciliated columnar variety, superimposed upon a basement membrane, which latter is made by a condensation of the inner part of the internal elastic layer. When the tube has reached the diameter of 0.2 mm. ($\frac{1}{50}$ inch), these cells lose their cilia, become shorter, smaller, and rounded, in the ultimate tubules becoming the simple pavement cells. Here the membrane loses its character as a mucous membrane, and resembles that which lines the alveoli (see art. Lungs). Here and there in the larger tubes are to be found the cup-shaped cells (*Becherzellen*) of Schulze, the function of which is yet unknown.

Vascular Supply.—From the thoracic aorta are given off the bronchial arteries, which, receiving occasionally branches from the first intercostal and internal mammary arteries, accompany closely the subdivisions of the bronchia, supplying their walls, the walls of the large pulmonary vessels, the lymphatic glands, and the connective-tissue of the lungs, to terminate finally in capillaries which inosculate freely with the respiratory plexus. Injections thrown into these vessels will fill also the capillary plexus of the arteria pulmonalis. The corresponding bronchial veins empty in part into the vena azygos, in part into the vena pulmonalis; the venous radicles from the ultimate bronchioles emptying into the

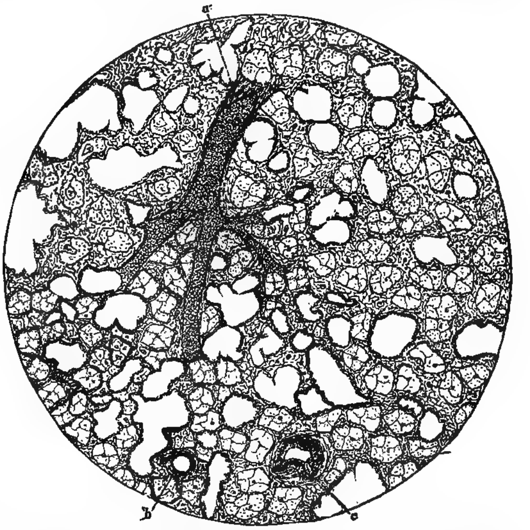

FIG. 526.—(Drawn by Dr. F. Cary, from a microscopical section, with camera.) *a*, A minute bronchiole splitting into the *ultimate* branches, which terminate in the alveolar passages; the epithelium has become of the simple pavement variety; on the left branch can be seen one of the so-called "saccular dilatations"; *b*, artery; *c*, medium-sized bronchiole having no cartilaginous lamina. The remainder of the field is normal lung tissue. (About 30 diameters.)

latter, those corresponding to the arterial branches to the bronchia and lymphatics, into the former.

Lymphatic Supply.—The lymphatics arise in the alveolar septa. Stomata open on the alveolar walls between the epithelial cells, communicating thus directly with the alveolar cavity. They form a plexus in the submucous tissues, accompany the branches of the bronchia, as well as the pulmonary veins and arteries, emptying finally into the bronchial glands at the roots of the lungs. Within the lungs they often possess a gray or black speckled appearance, from the absorption of pigment or foreign bodies.

Nerve-supply.—The nerve-supply to the lungs is derived from the pulmonary plexuses formed from branches of the vagus and sympatheticus. The filaments from these plexuses—situated at the lung hilum—follow the ramifications of the bronchia, becoming lost finally on them, and in the parenchyma of the lungs. When carefully stained they are seen to possess the microscopic ganglia in parts of their course, to which Remak and Schiff first called attention.

The sensibility of the bronchia must be very slight; at least in their smaller branches, because of the slight complaint made by consumptives in whom large portions of bronchial and lung structure are being destroyed.

Lewis L. McArthur.

BRONCHITIS. In no affection is the practical importance of the distinction between acute and chronic disease better illustrated than in bronchitis. A bronchitis of recent origin, or of sudden development, is hardly the same disease as a bronchitis of long standing, because, aside from the fact that they both involve the same locality, and that cough is a leading symptom in both, the essential features in the course of each are quite dissimilar. Moreover, in acute bronchitis itself, the conditions vary to such an extent, according to the part of the bronchial tract affected, that it will be more advantageous to consider capillary bronchitis separately. Hence we prefer, in beginning with acute bronchitis, to restrict the term to that common affection known as an acute catarrh of the larger and medium-sized bronchi.

1. ACUTE BRONCHITIS. — *Symptomatology.* — Nearly every one in our climate has experienced the first stage, at least, of an attack of this complaint. When a catarrh of the upper respiratory tract has been severe enough to pass beyond the larynx and trachea and become a veritable bronchitis, though yet only extending to the primary divisions, the symptoms are then readily distinguishable at sight from any other cough-producing affection. Pain is soon complained of and the patient's gesture in describing it is distinctive. Instead of applying his finger-ends against one side, as he does to indicate the stitch or side-stab of a pleurisy or a pneumonia, or holding his side as in pleurodynia, he lays his open hand on his breast as if taking an oath, and then passes it across the chest from side to side to indicate a suffocative sense of pain and tightness, which in severe cases feels as if the chest were transfixed with a disk of iron. Instead, also, of a carefully chosen and maintained decubitus, he changes frequently about, or else sits up and leans forward, a sure sign of a bilateral cause in dyspnœa, and one, therefore, which usually would exclude either a pneumonia or a pleurisy or phthisis. Although the patient may complain of difficult breathing, and although in active attacks he may breathe with both nostrils dilated, yet it will be noticed that, quite differently from what takes place in other febrile pulmonary affections, the respiration is but slightly accelerated; and, furthermore, the thermometer tells the same story in this as in inflammation of other mucous membranes, namely, that it rarely causes a greater rise than 100.5° to 101.5° F., unless some other element is entering into the course of the complaint. The other indications of a febrile complaint are usually present in a moderate degree also. The face is flushed, the eyes watery, the voice husky, the pulse somewhat faster than usual, the tongue furred, and along with a dry skin (not always) and headache there is also some chilliness, but not a distinct rigor, like that which ushers in a pneumonia.

The pain of bronchitis is an early symptom and often a sign that an acute catarrh, in its journey downward, has just entered the bronchi; for it is one of the peculiarities of the nervous supply of the respiratory tract that its sensitiveness differs markedly in different portions. The much greater irritability of the larynx over the trachea is well known, but it has been found by experiment that nearly the same proneness to cough on irritation is localized at the bifurcation of the bronchi. From this point onward, however, the irritability progressively diminishes, until, as a result, serious accumulations of fluid may form in the smaller bronchi without occasioning other symptoms than dyspnœa. This early inflammatory irritation will prove, on examination, to interfere with the breathing, mainly from spasmodic action of the bronchial muscles, conjoined with swelling of the mucous membrane itself, and consequent narrowing of the affected tubes, in much the same manner as the wide outlet of the nasal passage is closed in the beginning of a coryza. As soon, therefore, as a secretion bathes the irritated mucous surfaces, though the tubes be largely filled with it, the breathing becomes easier from relaxation of the spasm and reduction of the tumefaction, while the pain likewise is mitigated, except just after a fit of coughing.

Cough is a necessary element in bronchitis, and its sound indicates its character, so that a practised ear will distinguish it as bronchitic without difficulty. With reference to this subject of cough-sound, it may be said that all coughs can be divided, according to their sound, into two classes, whose nature and import may be recognized by simply hearing, without seeing, the patient. The first, or the irritant cough, is the result of direct or reflex irritation alone, and it neither produces expectoration nor is caused by any need for expectoration. It is always composed of separate coughs or hacks, which, however frequent and prolonged, or even though they be severe enough to prevent all sleep, are yet each independent of the other, like the blows of a hammer. The second, or the expectorant cough, on the contrary, is like the running of a chain over a pulley, and though it may be deliberate and slow, yet each cough is connected with the preceding and the following cough, and when once begun it will not stop until some expectoration has occurred. The patient, and all within hearing, are aware that the cough cannot be arrested until something is brought up, though, as in a case of viscid chronic bronchitis, the pellet which is dislodged, at last, seems an insignificant product for such a strangling time as the sufferer has had of it. To the irritant class belongs the characteristic hack of acute and of chronic pleurisy, and, therefore, also the ominous slight cough of early phthisis. It becomes, however, very loud and barking in hysterical or uterine cough. One of the most violent coughs which I have ever heard was in a lady who proved to have a polypus extruding from the os uteri, and as soon as it was removed this cough, of several years' standing, ceased. Children often have such coughs at night, from intestinal irritation, and the cough of thoracic aneurism is another instance of the kind, and lastly, it is the cough of direct laryngeal irritation, as in croup. This irritant cough, if present at all, is found only in the very first stage of acute bronchitis, and soon gives place to an expectorant cough, which is comparatively slow if moist, and rapid if dry; its conclusion in expectoration being always announced by the last one or two coughs being more or less liquid, and following after a short or very prolonged antecedent series, according to the character of the secretion expectorated.

In acute bronchitis, as just remarked, all cough is in the beginning painful. As each paroxysm ceases, the patient presses his hand againt the chest with an expression of distress, and in dread of the next return. After a while he experiences a good deal of soreness between the ribs, with some tenderness on pressure, which, however, must not be confounded with the same symptom in either pleurisy or pleurodynia, for in bronchitis it is located at the attachment of the diaphragm and of the other muscles engaged in the act of coughing, and is but the common result of unwonted muscular exertion.

Cough, therefore, is the chief cause of the patient's discomfort in acute bronchitis, and simply to allay it is the main indication in treatment. Hence the relief will correspond with the ease of expectoration, and this in turn depends upon the character of the secretion. As a rule, the secretion first formed is the most difficult of expectoration, owing to its viscidity. It is composed of a clear tenacious mucus, much mixed with air from the protracted efforts of coughing, and contains also a few mucus-corpuscles, and sometimes streaks of blood. After a time the secretion becomes either more liquid from greater watery admixture, or else more turbid and yellowish, according to the formation of a greater or less quantity of pus. This latter change, in acute bronchitis, is a sign pointing toward recovery, for as the expectoration becomes more purulent, it rolls into rounded masses of increasing consistency, but of less frequent formation, until but one or two such accumulations are expectorated in the morning, and then they cease altogether. When that desired termination will occur is uncertain, for the duration of acute bronchitis, like that of other

catarrhs, varies indefinitely, as it has no critical periods, and ends irregularly.

DIAGNOSIS.—Bronchitis is oftenest confounded with pneumonia, especially if the expectoration be bloody. From lobar (croupous) pneumonia we have already indicated some points of difference in the nature and bilateral extent of the pain, in the history usually of an antecedent naso-pharyngeal or laryngeal catarrh, in the absence of a distinct rigor at the beginning, in the moderate rise of temperature, and in the non-acceleration of the respiration. Physical exploration of the chest now completes the demonstration. In acute bronchitis there is no dulness on percussion anywhere, if anything, the stroke-note is increased in intensity all over the chest, and the vocal fremitus is diminished. In the early "dry" stage auscultation reveals sibilant asthmatic breathing in both lungs, varying constantly in intensity, and usually sufficiently marked to mask or extinguish the vesicular murmur. As soon as secretion commences, the whistling sounds give place to sonorous rhonchi produced in the larger tubes, mixed with the characteristic subcrepitant râle proceeding from the lesser bronchi. This râle is not as dry or sharp as the crepitant râle of pneumonia, and specifically differs from it in occurring during both inspiration and expiration, while the pneumonic râle is known by the wholly clear and high-pitched expiration which follows it. As the bronchial râle is itself often heard only at the end of inspiration, it should be watched for a number of respirations, and especially after coughing, when its true character will be revealed by its being heard also in expiration; or else it is greatly modified by the cough, while the pneumonic râle can neither be removed nor modified by any respiratory act. This distinction also separates the bronchial râle from a pleuritic friction-sound, which it often closely resembles, for whereas the friction-sound, like the subcrepitant râle, is heard during both inspiration and expiration, it cannot be modified by a deep inspiration or ever coughed away.

ETIOLOGY.—Bronchitis is sometimes an accompaniment of other acute diseases, like small-pox, but especially of measles and pertussis, and then it is apt not only to prolong convalescence, but also to cause permanent mischief by generating a proclivity to asthma. Its frequent occurrence in typhoid fever is due, as will appear further on, to the special muscle-weakening effect of fever, causing paralysis of the bronchial muscles and stasis of the bronchial circulation, and thus predisposing to a low grade of bronchitis when it is excited in the usual way, namely, by a partial exposure of the skin to some chilling impression when the patient is lying uncovered or in a draught. It is this external or surface origin of the great majority of cases of bronchitis which constitutes the most important, but at the same time the most obscure, problem of practical medicine. Excluding for the present the relation of phthisis to bronchitis, it is noticeable that bronchitis occurs only exceptionally as a direct result of some irritant property or ingredient of the inspired air upon the bronchial mucous membrane itself. The frequency of bronchitis among workers in dusty air, such as millers, rope-makers, etc., does not militate against this statement, for when every such instance is taken account of, it only shows that dusty air can cause bronchitis, as also measles does, but it does not explain why the great majority of cases of bronchitis have not been in dusty air at all. On the other hand, bronchitis can be produced almost to order by wetting certain parts of the skin and then exposing them to a current of air. A cold draught upon a person perspiring in sleep, even though it be upon a very limited part of the body, or sitting still with wet feet in a cool room, will induce a severe attack of the complaint much more commonly than the breathing of any air, however cold or hot or dry or moist it be. When the bronchial mucous membrane is already inflamed, especially in phthisis, it does frequently happen that sudden changes into very cold or into hot dry air excite coughing, but there are many things capable of aggravating an inflammation which yet could never produce it.

The susceptibility of mucous membranes to congestion and inflammation after some partial exposure of the surface of the body to chill is well known; but in every case —with the exception of the respiratory tract—it generally requires long antecedent disorder in the part before this susceptibility becomes well marked. Thus, in cases of chronic diarrhœa or dysentery, but especially in chronic cystitis and urethritis, the patients are often quickly visited with a relapse of their symptoms after a severe wetting, or after a chilling of the feet. Much the same benefit is also derived by such patients from removal to an equable climate, or from wearing a protective covering on the susceptible region and over the feet. But that condition which rarely befalls those mucous membranes, except in chronic inflammation, is a habitual state in the respiratory tract, though with varying susceptibility in different parts of that tract in different individuals, some being more liable to pharyngeal or to nasal, and others to bronchial catarrhs. It is thus plain that the association between the skin and the respiratory mucous membrane is more intimate than that between any other parts of the body. This fact should always be borne in mind and acted upon practically, although, so far, we know nothing of its cause or conditions. As a mere speculative suggestion we might refer to the demonstrated relations of the skin to respiration and to the maintenance of the mass of the circulation. In frogs the lungs may be cut out, and yet respiration be carried on for a number of days by the skin alone, for in the Batrachia the pulmonary artery divides into two branches, one going to the lungs and the other to the skin. Pettenkofer also found that when warm-blooded animals are covered with varnish, one of the most noticeable results, next to the sudden suppression of urine and the great fall of temperature, is that the excretion of carbonic acid by the lungs falls off at once, while the oxygen continues to be absorbed. The cause of death from sealing up the skin, which is also more speedy than if the abdomen be cut open and the kidneys taken out, has never been satisfactorily explained, for the supposition that it is due to the retention of a toxic cutaneous secretion is scarcely plausible; it is much more probably due to interference with a necessary function of the skin in relation to the respiration and to the circulation, for it should be remembered that, while the skin does not take up fluids, its absorption of vapors and of gases is of much wider range than the lungs, which can only take in oxygen and a few ethers. Though nitrogen enters the lungs with each inspiration, and in so much greater quantity than oxygen, yet none of it can pass the thin barrier of the air-vessels inward, any more than carbonic acid can traverse it, except from within outward. But the skin, on the contrary, readily absorbs the vapor of even heavy metals, like lead and mercury, and watery vapor is absorbed with such rapidity that experiments have shown that six pounds of water may be added thus to the circulation in less than half an hour. Workmen exposed to great heat in glass furnaces have been known to lose four pounds weight in an afternoon, and then to regain it after an hour spent outside without, meantime, eating or drinking anything. This rapid absorption of water renders the first entrance to a vapor bath so apt to produce giddiness, and, moreover, it is a real danger to persons with diseased cerebral arteries, or to those in whom the existence of dropsy shows that the circulation is already embarrassed. It may, therefore, be owing to some element in the relation of the functions of the skin to the respiration and to the circulation that a disturbance of the cutaneous equilibrum by change of temperature causes internal congestion, just as varnishing the skin so promptly causes hæmaturia and suppression of the urine. But we are still without any clue to the fact that mucous catarrhs, and all "colds," are so much more apt to occur from partial, and often very limited, exposure of the surface, than when the action of either cold or wet is general. Most colds, in fact, are caught indoors, from sitting, for example, on a winter day too near a window without weather strips, rather than from going out and facing the elements in all their fury. To attribute this to vaso-motor association is little better than an explanation by words, and yet there are some

facts of experience which show that there are particular associations in this matter which it is difficult to account for, except by supposing some nervous interdependence. A cold draught on the nape of the neck, in healthy individuals, is most apt to cause a coryza, especially if the hair of the back of the head be wet with perspiration; with patients who are already the subjects of pharyngeal or bronchial catarrh, such an exposure is likely to produce an increased irritation in the pharynx and bronchi instead; but in the normal state it is otherwise. A chilling of the anterior surface of the chest is most likely to occasion a bronchitis. Throat affections, whether pharyngeal or laryngeal, are the most likely developments after chilling of the feet. This particular relation is in keeping with the sensitiveness of the pelvic viscera to impressions of cold or of heat to the feet (*e.g.*, in menstruation, in cystitis, in irritable stricture of the urethra, etc.); while, conversely, nervous disturbances of these organs affect the voice, as in hysterical cough, aphonia, etc.

As remarked above, whatever the explanation or cause, it still remains indisputable that the beginning of most cases of bronchitis, as well as of most acute catarrhs of the respiratory tract, is in some chill of the skin. Such a chill is more likely to happen if the skin be wet by perspiration or otherwise than if it be dry, and particularly if it be simultaneously exposed to a draught of air, as the refrigerating effect of evaporation is then more than doubled. Hence bronchial catarrhs are common in hot and dry countries, provided that the nights are cool, for persons are then prone to be awakened in the latter part of the night by the need of more clothing, and often also by a cold induced by exposure while in perspiration. Otherwise the uniform experience of the world is that respiratory catarrhs in general, but especially bronchitis, are endemic wherever the climate is wet, windy, and prone to sudden cold changes. That this is not due to the injurious effect of cold air inspired by sensitive bronchi, is shown by the relative infrequency of bronchitis in the extreme cold of arctic winters, compared with its frequency in New England and Scotland. That it is not due to wetting the skin, is also shown by its infrequency in the wettest climate of the globe—in Penang and Assam. In temperate climates, therefore, the greater and oftener the changes from warm to simply chilly weather, the greater the prevalence of bronchitis, while the more equable the seasons, even if cold, the less is its frequency. The spring and autumn months, therefore, are in some localities the most dangerous, while in others this is true of the winter months.

Pathology.—Acute catarrh of the primary and medium-sized bronchi is rarely a dangerous complaint, and, if we consider its frequent occurrence, it is the least serious of any of the pectoral affections, particularly when compared either with laryngitis, on the one side, or with catarrh of the smaller bronchi on the other. A post-mortem examination, if it could be had, of an adult who, at the time of his death, was suffering from a severe chest-cold such as we are now considering, would reveal very little, if any, departure from health, owing to the removal of all traces of hyperæmia by the emptying action of the elastic fibres which line the tubes. It is far different in chronic bronchitis, while in diffuse bronchitis, which has travelled to the ultimate divisions, it is common to find the mucous membrane of the larger tubes also injected and red, especially at the points of bifurcation. In most cases, however, this reddening is in scattered points or patches, except in bronchitis which is secondary to heart disease, when it is usually stained of a uniform dark color.

Treatment.—There is no disease in this country which so often brings patients for a prescription as this form of bronchitis. This is not only due to its own exceptional frequency, and the discomfort which it occasions, but also to the just dread which a visitation of cough causes among most persons. Ordinarily, of course, they are mistaken in supposing that phthisis means a neglected cough, and therefore that "it will never do to let a cough run;" but there is cause enough always for shortening every bronchial catarrh in order to prevent the formation of a habit of the kind, which is common to all inflammations of the mucous membranes. Like a single attack of urethritis, so a single bronchitis is sometimes never wholly recovered from, but remains indefinitely at its original seat. The aim, therefore, should always be to prevent an acute bronchitis from becoming chronic, either actually or potentially, and hence, in this complaint, the less trust in nature, or in spontaneous recovery, the better. When called to a patient who has not passed beyond the condition of hyperæmia and swelling, generally termed "the dry stage" of bronchitis, the physician's first duty should be to induce secretion as quickly as possible. If the patient be not too young, or too old, or too debilitated, much the most effectual proceeding to secure this end is to dissolve a grain of tartar emetic in a teacup of water, and tell him to take a teaspoonful of this every ten minutes. As soon as he begins to be slightly nauseated by it his pain rapidly subsides, owing to the anæsthetic effect of antimony; the spasm of the bronchial tubes relaxes, and soon a watery secretion flows and expectoration begins. It is not necessary to carry the administration of the antimonial to the point of producing emesis, for it cannot abort the inflammation, and we have much better remedies for the succeeding stages of the complaint.

As we have remarked before, cough is the one symptom to combat in acute bronchitis (not bronchiolitis), for it is apt to do a great deal more than produce expectoration. In acute (not chronic) inflammations the first indication is to secure quietude of the inflamed part, and every act of cough is an infringement of this rule. The severe pain which each paroxysm causes proves the mischief which it occasions, and hence, as some coughing must occur in order to remove the secretion formed, the purpose should be to render the secretion capable of removal by as few acts of coughing as possible, and then to suppress the superfluous remainder. Hence the more watery and the less adhesive the mucus can be made, and the less reflex irritation there be from the inflamed part, the sooner will the bronchitis subside. To fulfil the first indication, namely, that of inducing a watery flux, the most efficacious remedies are oils. To prove this one need only introduce a few drops of sweet-oil into his nose and note the flow which will speedily follow. The action of castor-oil on the intestinal mucous membrane is another illustration of the action of oils, and we may mention in passing that castor-oil on this principle is a dangerous cathartic to give to infants with bronchitis, from its tendency to fill their small tubes with too much secretion. Now certain oils have a particular affinity for the bronchial mucous membrane, and hence have a right to be classed among expectorants, and one oil, the oleum lini, or linseed-oil, has this property to such a remarkable degree that it is one of the very best means at our disposal for painful bronchial coughs of every kind, including phthisical bronchitis. On this account the prescription which I use oftener than any other for acute bronchitis is an emulsion of this oil with sedative neurotics, somewhat after the following formula: ℞. Ol. lini, ℥ ij.; pulv. acaciæ, ℥ j. ʒ ij.; aq., ℥ iij.; glycerinæ, ʒ vj.; syr. simpl., ℥ j. ʒ ij. M. Ft. emulsio, et adde ol. gaultheriæ, ol. cinnamomi, āā ♏xv.; acid. hydrocyanici dil., gtt. xvj.; chloral, ʒ ij.; morphiæ sulph., gr. j. Sig.—One tablespoonful four times a day. In a large proportion of cases the "loosening" and quieting effect of this prescription is immediate, and, if there be much asthmatic wheezing, it answers to add the tinctura belladonnæ, ten drops or so, to each dose.

Where the bronchitis develops in the course of a descending catarrh from the pharynx and larynx, and especially in those with laryngeal pain, the action of full doses of aconite is very beneficial. A combination of tincture of aconite and camphorated tincture of opium with spirit of nitrous ether and syrup of senega may be employed for the same purpose as the linseed-oil emulsion, especially in patients who dislike all oily mixtures. Iodide of potassium, in doses of four grains, also comes under the head of liquefying expectorants, and to a less degree the carbonate of ammonia.

After a few days, in many persons the secretion often increases, especially in those who have had repeated at-

tacks, until it becomes a very inconvenient and obstinate bronchial flux. Here the indication is for a combination which will start secretion and at the same time not allow it to become too viscid. Dr. C. J. B. Williams' favorite prescription for phthisical bronchitis, with abundant expectoration, is useful under these circumstances; it contains nitric acid, iodide of potassium, syrup of senega, and balsam of tolu. The addition of belladonna renders it still more certain in diminishing the flux.

The use of hot drinks on going to bed, especially those containing alcohol, for the purpose of getting up a perspiration, should be reprobated. Alcohol is uniformly mischievous in all catarrhs, acute or chronic, and the benefit of perspiration can be much better obtained by a Dover's powder and aconite taken while the patient wraps himself in an extra covering and sits with his feet to a fire without moving from it for some hours until he can go directly to bed. This, then, should not be too warm, for a nocturnal perspiration is always risky.

Counter-irritation is justly reputed among the laity as of much service in bronchitis. At the very start, a sinapism to the chest, especially if made large and applied for only a short time, may cut an attack short. After the second day it is rarely of any use, and furthermore it should never be applied in measles, as the action of mustard on the skin when inflamed by measles is apt to be very severe, and I have known of two fatal cases, in children, of gangrene of the surface of the chest from the ignorant use of mustard in this exanthem. Stimulating embrocations, however, such as the soap liniment, with turpentine and aqua ammoniæ, are useful both in the onset and decline of bronchitis, if only to lessen the cutaneous hyperæsthesia or sensitiveness to draughts, which accompanies all severe catarrhs of the respiratory mucous membrane.

2. Acute Bronchiolitis, or Capillary Bronchitis.—This formidable disease, with a mortality from thirty-five to fifty per cent. of all attacked, is much more than a simple bronchitis, for the accompanying inflammation not only extends beyond the terminal bronchi into the alveoli, but also affects the peribronchial tissue, and may even involve the pleura. The affected tubes lie far within the substance of the lung, and, having lost all cartilage, they ramify as small thin membranous channels between textures rich in blood-vessels and in meshes of connective-tissue. An inflammation reaching to them, therefore, may thus give rise, by involving the surrounding structures, to both acute and chronic changes of greater constitutional effect than in the case of any simple mucous catarrh. A pretty sure indication of this fact is found in the sudden rise of temperature which is observed whenever an acute bronchitis is passing into a bronchiolitis, for this proves that a profounder reaction has occurred than pertains to the course of a mucous membrane inflammation. It is difficult, indeed, to draw a sufficiently marked distinction between the lesions which are apt to arise from the extension of a bronchiolitis and the phenomena of so-called catarrhal pneumonia. The term catarrhal has been objected to as applicable to a pneumonia, because the air-cells cannot be said to contain mucous membrane, but the significance is obvious enough as indicating a pulmonary consolidation arising in a pneumonic process whose origin really comes from the bronchial tubes. While, therefore, capillary bronchitis as such is a frequent disease of early childhood, and often proceeds to a fatal termination without general implication of lung-tissue, in adults pneumonia, consecutive to diffuse bronchitis, is a common affection, especially in the aged or feeble, or when supervening upon a chronic bronchitis. In these patients greater areas of consolidation are found in both lungs than is common in children; but it is difficult to demonstrate any specific difference in the morbid processes themselves, as the gradations between the two are of every degree, the smaller bronchi being almost exclusively affected in some adults, and pneumonic consolidation being the most pronounced lesion in many children.

The main reason for the gravity of capillary bronchitis is to be found in the comparative weakness of the bronchial muscles of patients affected with this disease. This cause pertains equally to the affection in children and in the aged. The muscular coat begins in the trachea and in the primary bronchi, where it joins together the free ends of the incomplete rings or C-shaped cartilages, and can thus, on occasion, contract the calibre of even these larger tubes. As the bronchi further divide, the muscular layer relatively increases, becoming more or less a circular coat, until it ends at the alveolar passages as a thick bundle of annular muscle fibre-cells, forming a kind of sphincter (Rindfleisch). Upon the muscular layer lies the thick layer of longitudinal yellow elastic fibres which are continued on into the texture of the air-vesicles themselves. Now, as the one function of muscle is to produce movement, it is plain that these muscles, acting upon the recoil of the elastic fibres at the moment when the external expiratory muscles are driving the air through the tubes in coughing, could, by a quick contraction upon the current of air, greatly assist the propulsion of fluids toward the larynx.

In children the bronchial muscles are not only relatively of much less development and power in proportion to their youth, but they are equally weak in the muscular apparatus of the throat and in the expiratory muscles of the chest, the latter having the further disadvantage of the yielding nature of the chest-walls to which they are attached. Young children, therefore, cannot clear even their throats of mucus, but rather swallow that which is brought up, and in proportion to their debility, whether due to age or to imperfect development, will the danger increase of suffocative accumulation in their air-tubes. In the aged, on the other hand, bronchial palsy, consecutive to chronic bronchitis, is the commonest condition which leads to a fatal complication.

Capillary bronchitis affects children more commonly in the first year of life, the frequency then diminishes progressively up to the third or fourth year; and, finally, the disease may develop from any of the common causes of acute catarrh of the respiratory tract. It is, therefore, of exceptional severity in whooping-cough, and ranks as the commonest cause of death in measles. It occurs also during the winter months, as one of the complications of dentition. At other times it develops upon an ordinary cold, which has begun with sneezing, and, after setting up a coryza, goes on to develop laryngo-tracheal symptoms for several days, until finally symptoms of a more pronounced constitutional kind begin to manifest themselves. The child becomes heavy and drowsy, with longer and more severe paroxysms of coughing, followed by dyspnœa, which is evidently due to paroxysmal spasmodic action in the bronchial tubes. After a time the nostrils begin to be permanently in action, a constant restlessness sets in, the respirations become accelerated, the head grows hot, and the face is deeply reddened during the attacks of coughing, which, though very hard, yet do not bring up much secretion. The cough has a peculiar whistling character, quite different from the brassy sound of croup, and a distinct wheeze is audible in many cases without applying the ear to the chest. The thermometer now shows that a rising fever is on hand, for a temperature from 102° to 103° F. in a child with a cough should always cause solicitude. Percussion at this stage does not afford much information, but later on it may reveal localized areas of dulness, especially in the infrascapular and subaxillary spaces. Auscultation sometimes affords nothing but highly puerile respiration, but oftener a great number of high-pitched fine sibilant sounds are heard accompanying both inspiration and expiration. The presence of areas of consolidation is sometimes made out by localized exaggeration of both breathing and voice-sounds, especially after a fit of coughing. It should be remembered that a child's chest, being so much smaller relatively than an adult's, is proportionately more resonant, and often transmits sounds of all kinds over to the side opposite to that on which they originated.

Meantime, with the progress of the case, both pulse and respiration grow more and more frequent. The child can nurse or drink only with a short, hurried effort, and, as the respiratory obstacle increases, its chest begins to show

signs of disordered breathing which are very significant. The lower ribs and the epigastrium sink in, during inspiration, indicating widespread obstacles to the ingress of air. On the other hand, the residual air in the lungs both increases and becomes rarefied, so that the supra- and infra-clavicular spaces become distended and the upper part of the chest seems scarcely to move with the breathing. As the case progresses the body-temperature varies from 102° or 103° in the morning, to 104°, 105°, or even more, in the evening. The pulse rises from 150 to 180 or 200, and the respirations to 50, 80, or 100, per minute, while the constant tossings of the patient and its expression of terror too plainly indicate the dread of approaching suffocation. As might be expected from the lack of air, its cry is low, plaintive, and short. If relief does not come, signs of exhaustion, from the excessive labor of the breathing, begin to appear; the lips first turn blue, the face and surface generally become cool, pale, and livid, the pulse grows thready, the cough ceases, and the stupor of carbonic-acid poisoning grows deeper until death closes the scene, with or without slight convulsions.

The duration of the disease is not very definite. In favorable cases it may last ten days and then occupy a week in recovery, with increased but more expectorant coughing at first, and with a plain increase of inspiratory power. In others who recover, the febrile stage may yet last for from three to four weeks. In a certain proportion of cases the disease passes into a fibroid alteration of extensive regions in one or in both lungs. As the inflammation then becomes chronic the peribronchial connective-tissue greatly hypertrophies, causing more or less obliteration of the air-cells, and, finally, adhesions of the thickened pleura to the chest-walls. Great bronchial dilatation is then apt to follow in the consolidated parts, surrounded by emphysematous lobules, and a constant secretion of muco-purulent sputa is thrown off. These symptoms, combined with the great emaciation of the patient, seem to leave nothing wanting for the diagnosis of tubercular phthisis. Often, however, so much improvement of a permanent kind occurs, if the patient survives for a few years, that the prognosis need not be as hopeless as the same degree of wasting would imply in an adult.

The post-mortem appearances, after capillary bronchitis, vary according to the participation of the lungs in the inflammation. If the case has been chiefly bronchitic, the lungs do not collapse when the chest is opened, but may even bulge out as if they had been compressed by the ribs. This pseudo-emphysema is caused by the occlusion of the bronchi by mucus and other products of the inflammatory process. Commonly, however, the surface of the lungs is irregular from alternate collapsed and over-distended lobules, according as the valve-like action of the secretion in the tubules had allowed more air to pass during inspiration or more during expiration; the condition of over-distention being produced when less air could be forced past the obstacle during expiration than during inspiration, and a condition of collapse being produced when the reverse was true. The bronchi, which are universally stuffed with mucus, pus, epithelial-cells, etc., show very generally a reddish and swollen mucous membrane, this condition extending even to the primary bronchi, if not to the trachea; in which respect the appearances presented in this disease contrast strongly with those observed in simple bronchitis.

Treatment.—We scarcely need say that the treatment of capillary bronchitis should be prompt and decisive, and hence according to clearly defined purposes. As soon as the thermometric rise and the other symptoms indicate the threatening approach, the aim should be to shorten the acute stage of the inflammation as quickly as possible. For this purpose aconite is the best medicine, and should be given with the set determination to make the patient feel it. Every two hours doses of one, two, or three drops of the tincture of the root, in a solution of citrate of potash, should be given until the pulse falls in frequency and "excitement." Should the pulse grow weak or intermittent under this course, the use of stimulants will soon show that the acute inflammation is itself a guard against too great doses of aconite, for only a few teaspoonfuls of brandy will be enough soon to counteract the depression of aconite, which in a normal state, or in a chronic disease, would continue for hours. There is no remedy which can do as much as aconite just at this juncture; later on it is mischievous, but at the beginning it is much the best antipyretic and antiphlogistic that can be employed, because of its specific effect in lessening the initial engorgement of the respiratory mucous membrane when acutely inflamed. We see this exemplified in tonsillitis, in which disease, when given in full dose, it often cuts short the otherwise tedious course of the affection toward suppuration; and a like power to prevent the congestion and the formation of muco-pus may be fairly attributable to it in bronchitis, while its anæsthetic effect is beneficial both to relieve the pain and to control the consequent asthmatic spasm of the bronchioles. We do not have the same reason to fear cardiac weakness in capillary bronchitis of children as in the aged, for the heart of the child is relatively stronger than that of the adult, at least as regards the right side, which has about the same thickness in early life as the left.

When sibilant râles begin, we should add, and continue systematically to give, the tincture of belladonnæ in full doses, combined with half a drachm to two drachms of the spirit of nitrous ether, in sweetened water or milk, every three or four hours. This combination is not to be omitted until convalescence begins; for while the aconite may be dropped as soon as signs of exhaustion appear, or if the temperature is relatively low, the belladonna and nitre should be faithfully persisted in as respiratory stimulants, to strengthen the function most imperilled and also to lessen the complication of bronchial spasm.

Then when moist râles, a recurrent dyspnœa, and exciting hard cough come on, we have a plain indication to try and expel retained secretions. Here a single emetic, administered every twelve hours, is of true service. Some writers condemn emetics on the ground of failure, in their experience, to afford relief by their use. If wrongly administered, emetics are not remedial in bronchitis, but dangerous instead; still, that is no reason for neglecting the most efficient method of expelling mucus in children. Vomiting is both natural and easy to children, while expectoration is much the reverse, and no one who has witnessed the great relief following upon the effective action of the abdominal muscles after an emetic, in dislodging a quantity of mucus where the hardest coughing of children had failed to produce any effect, will doubt that emetics can do great good in the hands of those who know how to use them. In the present instance, neither antimony, ipecacuanha, nor apomorphia should be employed, because they excite too much bronchial secretion, and hence when they do act they give but the most evanescent relief. Often also they fail to act as emetics at all, whereupon their effect is bad, for nothing is so calculated to fill the tubules with liquid as a prolonged nausea. Instead of these emetics we would recommend, first, the turpeth mineral, or yellow sulphate of mercury, in doses of two to five grains; or, second, the sulphate of copper, half a grain; or, third, the sulphate of zinc, in a dose of five grains combined with the same amount of powdered alum, in a tablespoonful of water. None of these emetics operates except in the one way of irritating the nervous association with the gastric nerves to expel a gastric irritant. The heart is not depressed by them, nor the bronchial mucous membrane rendered œdematous, and moreover, if emesis does not follow very speedily after their administration, they do not act at all, and may safely be left alone, as far as the bronchial membrane is concerned, if a second dose has not been followed in ten minutes by vomiting. The case then is not one in which emesis should receive further trial, at least for another twelve hours. A more frequent administration of emetics than once in twelve hours is useless.

When the struggle for breath once begins in deadly earnest, the indications change to the two purposes of supplying oxygen and of sustaining the patient in the dread struggle. Why should the necessary restlessness of the patient be now smothered by opium? It is difficult to see any reason for the employment of this drug,

from first to last, in this critical disease, other than that of securing the deceptive quiet which this most effective paralyzer of respiration may occasion in bronchitis preparatory to a quiet forever permanent. That opium is a cardiac stimulant is quite true, if the cause of the heart weakness be *abdominal*, but not otherwise; and meantime opium always slows the respiration, causes retention of carbonic acid, and weakens the bronchial muscles. A much better relief to the distress and cough is afforded by a mixture of chloral and camphor, to which a very small quantity of an opiate is added, as in the following: ℞. Chloral, ʒ j.; Magend. sol. of morphia, ♏x.; syr. simpl., ℥ ss.; aq. camphoræ, ad ℥ ij. M. Sig.: Teaspoonful in sweetened milk. In the meantime, if pure oxygen gas can be procured for inhalation, we can speak very favorably of its aid in battling for life in these cases, both by assisting the breathing and by strengthening the heart. On this account, the air of the room in the immediate neighborhood of the patient should be constantly renewed, while, at the same time, any chilliness noticeable in it should be counteracted by artificial heat, tempered with steam. Inhalations of steam vapor are not called for, if laryngitis is absent, inasmuch as the necessary measures for steaming may interfere with the free supply of oxygen.

The indications to sustain the patient's powers now call for the most fearless use of alcoholic stimulants. Of all such preparations brandy does best for children, and may be given to them with or without milk, generally best in some hot liquid; in the suffocative stage of bronchitis it may be given continuously in doses of one, two, three, or even four drachms every hour. It will be noted, now, that cardiac stimulants are of the most service, and hence *external* irritants will often greatly aid the other measures adopted. While an external covering is of great value in the first onset, and then the more soothing its effect the better, exciting ones are the effective means at the last. We would recommend, therefore, a jacket of wadding for the chest, covered with oiled silk, during the early stage of the complaint, to be followed later on by baths in hot mustard-water. The latter should be taken once in six hours, and should be continued each time until the skin is reddened; and occasionally a cloth wrung out of a hot infusion of capsicum, ʒ j. to the pint, should be applied to the chest for from five to ten minutes, and then the wadding jacket should be put on again as before. Another good point in practice is to give an infant who is struggling for breath something hot to swallow every few minutes. Half a teaspoonful of hot milk and lime-water, or some such excitant of the act of deglutition, powerfully helps expectoration, as I have had frequent occasion to note, as well as relaxes bronchial spasm. Kroenecker found that every act of deglutition acts as a cardiac stimulant, and raises the blood-pressure.

Many of the favorite remedies employed by different writers in the treatment of broncho-pneumonia can only be mentioned briefly, because, having tried them, we are too uncertain of their beneficial effects to prescribe them hereafter in cases of our own. First, ammonia, as a cardiac stimulant and expectorant, is largely employed, and in older children may be beneficial, as it certainly is in the pneumonia of adults. The difficulty with it in little patients is the irritation which its administration, however disguised, causes in them compared with adults, for it excites both coughing and crying. Chlorate of potash is relied upon by many also, but is of doubtful utility in any except diphtheritic cases. Quinine is given in pulmonary inflammations with the same regularity at present as blood-letting was resorted to half a century ago, and with no better reason. Aconite is a far more certain antipyretic than quinine in this complaint; while the depression produced by quinine upon the heart is decidedly more permanent than that of aconite in children, and, at the same, time there are no compensations to warrant its administration.

3. Chronic Bronchitis.—This common disease, unlike the preceding, is usually a complaint of middle or of declining life, and fully illustrates in its course the inveteracy and proneness to relapse of all chronic disorders of mucous membranes. Although the structural changes which chronic bronchitis induces may become very extensive and may involve secondarily the most distant parts of the body, producing changes in the abdominal viscera and in the entire circulatory system, yet it always remains essentially a local and not a constitutional disease. This is a matter of practical importance to the physician, and is well shown by a comparison between chronic bronchitis and pulmonary phthisis, the disease with which it is most apt to be confounded, on account of the most prominent symptoms of each being cough and profuse expectoration. Thus, a significant difference meets us at the outset in the personal appearance of patients, even in the advanced stages of these two complaints, and one which indicates a difference of both nature and origin. Phthisis, from the beginning, is a wasting constitutional disease, frequently manifesting a loss of bulk in every structure which is related in any way to the function of respiration, before any respiratory changes can be detected, except perhaps quickened breathing. The early contraction, or want of action of the lung-apices, produces a characteristic elongation of the neck from sinking down of the clavicles, which causes the patient to carry his chin forward beyond the line of the chest and abdomen. The muscles of the neck also appear thin and ribbon-like, although the imperfect respiration causes these auxiliary muscles to stand out more plainly under the skin in forced inspiration than they do in health. Following upon this change in the neck, there is a peculiar retraction of the cheek toward the angle of the jaw, while the early emaciation appears in the pinched features, the sharply defined nostrils and ears, and the too clear conjunctiva, which shows the sclerotic through it like a polished glass ball. The hands, which in all cases show emaciation better than the face, look bony, and have a bird-claw contour, from wasting of both dorsal and palmar muscles; while the bones generally, like the muscles, have a tendency to be narrow and thin. The skin of the consumptive is of silky smoothness, with long blue veins, and, except at the onset of the daily fever, is moist as well as soft. In contrast to all these characters, a case of severe bronchitis presents us with a round and much distended chest in the very region where it is flattened or sunk in phthisis. The clavicles, therefore, are elevated instead of depressed, and the neck is directly shortened. The chin, instead of being carried forward, is drawn back, and the neck muscles are large, broad, and massive, being much hypertrophied by the labor which they are called upon to undergo in lifting the chest, because in chronic bronchitis the vertical movement of the chest-walls is increased in proportion as the lateral and the antero-posterior movements are decreased. Chronic bronchitis, moreover, being a non-febrile disease, does not cause atrophy of the muscles, and hence the powerful array which may be seen under the skin of the neck whenever coughing begins. Owing to the same cause, the supraclavicular depression, which is nearly obliterated in phthisis, is much deepened in bronchitis, in some instances sufficiently so to admit of several fingers being laid in the cavity; and if emphysema also be present, quite notable tumors rise from the bottom of the depression during coughing, which are caused by the distended subclavian and innominate veins. The face is turgid, the complexion is often suffused, the nose and ears are thickened, the conjunctiva has an œdematous appearance and is traversed by tortuous veins, while the skin, particularly if emphysema and consecutive chronic hepatic congestion be present, is dry and leathery, and can be drawn into wide, non-elastic folds. Everywhere under this thickened skin the veins appear enlarged, tortuous, and dark-colored.

Symptomatology.—The most common history of a chronic bronchitis is that the patient was at first subject to frequent attacks of acute bronchitis, especially in the last weeks of winter or in a belated spring. His cough, he tells us, hung on by his taking a fresh cold every time he went out or the weather changed; and he tells his story correctly, because he had reached that state of susceptibility to relapse on slight provocations which is the penalty of leaving an inflammation of a mucous membrane only partially healed. Just as an old gleet will return after some trifling

error of diet, so does a bronchitis revisit its victims upon the slightest chill or exposure to a draught of air. So soon, however, as milder weather comes, when the skin is kept in a state of gentle perspiration, the bronchitis is displaced and the cough ceases until the chilly season comes round again, when the same experience is repeated, with an increase, each year, of the severity or the duration, or both, of the bronchitic attacks. After an indefinite length of time, according to the individual case, the cough becomes permanent, and merely decreases in severity during the favorable season. But meantime it is worthy of note, that not until long after the bronchitis has become continuous, so to speak, does the patient's general health seem to suffer materially ; for, in great contrast with a true consumptive after the same lapse of time, he loses but little in flesh or color, and in summer often seems quite well. Prolonged cough, however, at last begins to tell, and the first sign of injury is usually breathlessness upon muscular exertion. This is mainly due at first to weakening of the air-vesicles by overstrain, and may be entirely recovered from. Another complication is soon added, which in some individuals comes on much earlier, namely, asthmatic breathing. This is a most unwelcome addition to a bronchitis, for it rarely parts company with it thereafter, and meantime greatly increases the textural mischief wrought by the primary disease. In time dyspnœa becomes habitual, whether the patient has been coughing or not, and, ere long, signs of embarrassment of the pulmonary circulation develop from weakness of the right ventricle, the far-reaching results of which are now to be detailed.

The cough of chronic bronchitis is varied in character according to the quantity and quality of the secretions expectorated. One kind has been graphically termed "dry" catarrh, from the small amount but great viscidity of the discharge. This secretion can scarcely be propelled along the bronchial walls, and when it reaches the bifurcation of the trachea the most violent and rapid paroxysms of coughing commence, in which reflex laryngeal spasm participates, causing the sound to become like a whistling squeak. The patient has to use every expiratory muscle to the utmost, and doubles himself up with the effort, while his face grows purple and his eyes and nostrils water, until the tenacious streak of mucus is finally dislodged with much gagging or even vomiting. This severe coughing naturally produces injury of the small bronchi and of the air-vesicles from mere mechanical violence, so that emphysema is more likely to occur in this than in any other form of bronchitis.

The other and more common form is that in which the secretion is abundant and liquid. The amount and consistency of this, however, vary greatly. Some are able to get rid of the most of it at one fit of coughing, and then remain measurably free for hours ; others have a steady flux, which rarely allows them any prolonged intermission in their efforts at expectoration. This bronchorrhœa is apt to be particularly harassing at night, and is the torment of many old persons, who can rarely lie down after midnight. In the majority of cases this condition is dependent upon cardiac weakness, and hence, even in the best summer weather, when the cough is much mitigated although still moist, râles will be found to prevail at the bases of both lungs posteriorly.

The character of the expectoration of these patients varies, also, in other respects. In some, the watery flow is markedly predominant, and, when expectorated into a vessel containing water, the muco-pus floats in irregular masses on the surface, owing to the air which is entangled in its meshes. In others, pus itself is raised in great quantities and in rounded masses. In still other cases, however, which are usually of long standing, the expectoration is very liquid in parts, and of a brownish tinge ("prune juice"), with masses of fetid, purulent, and rather adhesive secretion which sinks to the bottom of the cup. This fetor has been interpreted as a sign of prolonged retention in some cavity on the way, and therefore an evidence of sacculated enlargement of the bronchi. While this is doubtless true of most cases, yet it is not so of all, and the fetid secretion may then be caused by some special putrefactive ferment in the bronchial wall itself. This is rendered possible by the curious fact that the fetor is so much greater in many instances than is found in the largest phthisical vomicæ, and, moreover, is so much less easy to disinfect. It is sometimes difficult to distinguish it from the odor of gangrene of the lungs, and the diagnosis has to be based upon the different antecedent history and subsequent course. The breath also often remains offensive after the expectoration has chiefly lost its odor ; at other times, the fetor comes and goes without any assignable reason. Neither is it necessarily a dangerous complication, for the worst case, as regards odor, that I have ever seen was in a young man who had it for several years, while his general appearance continued extremely good.

Acute Broncho-pneumonia supervening upon Chronic Bronchitis.—Chronic bronchitis may terminate rather suddenly by the supervention of an acute diffuse bronchitis with consecutive pneumonia. There is reason to fear an access of this kind if a patient, who has suffered from this complaint for a long time, begins to feel chilly and feverish. A development of fever in a comparatively non-febrile complaint like this, is always of serious significance, as it is in the bronchitis of children. The cough becomes much more severe and exhausting, and the implication of the smaller bronchi is rendered probable by the characteristic appearance in the sputa of long threads of mucus hanging down from the larger masses as they float in the more liquid portion. These mucus-strings are derived from the smaller bronchi, which they nearly occlude until expelled by great effort, and, if the patient's strength fails, the symptoms rapidly assume a grave constitutional character. The cough grows more and more ineffectual, the fever increases, and a low delirium sets in, with much subsultus tendinum, a dry tongue, and often free sweating. It is an unfavorable sign when the patient no longer attempts to sit up, or to turn on his side, or when the cough ceases. Physical exploration shows the ordinary signs of broncho-pneumonia, and while the prognosis is always serious, it is worst when among the antecedents there has been a weak, dilated heart, emphysema, bronchiectasis, or old age.

Pathological Anatomy.—There is no disease the general course of which is better explained by its morbid anatomy than chronic bronchitis. The changes that are found after death are so manifestly explanatory of the ante-mortem history that both the symptoms and the sequelæ of chronic bronchitis are best understood by keeping in mind the organic alterations which produce them. After chronic bronchitis, there is usually found considerable discoloration of the lining mucous membrane of the bronchi, either brownish and generally diffused, especially if the case has been complicated by cardiac disorder, or else in scattered red points, which increase to patches about the bifurcation of each bronchus. Of greater significance, however, than these vascular signs is the hypertrophy of the mucous membrane itself, which shows also a very irregular surface from still greater thickening of the subjacent longitudinal elastic fibres and hypertrophy of the muscular coat. Like all hypertrophied unstriped muscular fibre, the muscles are frequently found in a state of fatty degeneration, and evidently possess but little of their normal contractile power. This is especially the case in the sodden tissues found in bronchorrhœa. The bronchi themselves appear to be passively dilated, and, on section of the lung, multitudes of the tubules are found to resemble the primary divisions in calibre, until further examination shows that they spring from smaller bronchi than themselves. The secretion found differs according to the form of the disease in life, being highly purulent and tenacious in the so-called dry catarrh, and filling all the smaller divisions with watery mucus in those characterized by more flux. It is, however, as we proceed further into the adjoining tissues that the most instructive lesions are found. Emphysema, as might be expected, is always present to a lesser or greater extent, sometimes occupying mainly the edges of the lung, at other times spreading out in every direction, interspersed with bands of fibrous tissue which

strikingly assimilate the appearance of the viscus to that of a case of fibroid phthisis. The recent demonstration, however, of the specific nature of tuberculosis and its dependence upon a parasitic organism, renders it as incorrect to speak of a bronchitis turning into phthisis as of a urethritis changing into syphilis; while of course it is not denied that a peribronchial inflammation, due originally to a chronic bronchitis, may afford a good nidus for the reception and development of the phthisical virus. The common accompaniment of fibroid thickening from any cause, namely, the development of bronchiectatic cavities, leads to a still further resemblance to phthisis, and one which, in some cases, makes it difficult to settle the diagnosis without a full history of the beginning and course of the disease.

Besides the production of emphysema, one of the common results of chronic bronchitis is a slow implication of the surrounding connective-tissue, which, as we have seen in capillary bronchitis, occurs with great rapidity. Peribronchitis is distinguished by a tendency to pass from lobule to lobule outward, until it involves the pleura and produces thickening of that membrane. This effect has been ascribed, by some, to an extension of the inflammatory changes along the nutrient channels, which belong to the bronchial arterial system, rather than to those of the pulmonary vessels. One result is a great fettering of the expansion of the lungs in this complaint, so that on inspection of old cases we often find the lower ribs contracted, and either wholly immovable or else falling in with each inspiration, the only well-marked thoracic movement being vertical, and carried on mainly by the neck and shoulder muscles.

The results of such changes upon the circulation now remain to be briefly considered. It is inevitable that the right ventricle should sooner or later become enlarged and dilated by the prolonged obstruction caused by the disease in the pulmonary circulation. Universal venous congestion, therefore, is a common result of a bronchitis which has lasted long enough to embarrass the outflow into the lungs. Brown induration of the liver, with gastro-intestinal derangement, follows. The marasmus of chronic hepatic disease shows itself over the body in the dry, thickened, and wrinkled skin, in general arterial rigidity and muscular atrophy, and in a tendency to interstitial increase of connective-tissue throughout all the organs. Hence old bronchitic cases, instead of resembling the soft, white, emaciated forms of the phthisical, much oftener look like the withered and dusky sufferers from cirrhosis of the liver. The portal congestion induced by the hepatic obstruction produces gastric catarrh, constipation, and hæmorrhoids, and later the kidneys partake in the venous stasis, so that the urine becomes scanty and high-colored. As the return current of blood becomes more and more impeded, ascending œdema from the feet develops on to general anasarca, in the usual fashion characteristic of cardiac dropsies.

Etiology.—The causation of chronic bronchitis is dependent, in the majority of cases, upon recurrent acute attacks, as just described. The original proclivity to such attacks, however, undoubtedly varies in nature in different cases. Some persons seem to have a hereditary diathetic tendency to bronchial catarrh, beginning generally with a chronic sensitiveness of the pharynx. These cases are characterized by imperfect circulation of the feet. There are a number of individuals, however, who are prone to chronic hyperæmia of all mucous membranes, which shows itself in swollen and reddened eyelids, and in chronic nasal, pharyngeal, or aural inflammations; they also have disorders of the abdominal viscera, accompanied by sediments in the urine, etc., all of which ailments seem connected with some irritant in the blood from mal-assimilation; and when persons of this class contract a bronchitis they seem never to get rid of it. That the gouty diathesis disposes to chronic bronchitis is well known, but so also do all sclerosing disorders, such as chronic alcoholism, with or without cirrhotic changes in liver or kidneys, and particularly when arterial degeneration is added. Lastly, mitral valvular disease leads to bronchial stasis and flux, the more so on account of the peculiarity of the bronchial arteries which communicate freely not only with the general systemic veins, but also with the pulmonary veins—vessels, therefore, which lie in the direct track of a mitral obstruction.

Diagnosis.—The diagnosis of chronic bronchitis is difficult only where the discrimination has to be made between it and fibroid phthisis or chronic pleurisy. The points in which it differs from phthisis have already been reviewed. Fibroid changes in the lung, however consecutive to chronic pleuritic adhesions, are very analogous to those in many cases of chronic bronchitis; but the initial history of the former is very different, as it begins with pleuritic pains and continues frequently to repeat this symptom to the last. Similar pains also characterize the course of fibroid phthisis to a much greater degree than they do bronchitis. Physical exploration of the chest is not very satisfactory in chronic bronchitis, from the too great number of signs. Aside from a few cases with pleuritic adhesions, the sounds obtained by percussion are usually not much altered from the normal except in the direction of increased resonance. Auscultation, however, meets with nearly every sound which can be generated in the chest. When we reflect that in a well-marked old case we may have a much greater than the usual number of large tubes, filled in varying degree with various kinds of secretions, in close proximity to asthmatically narrowed bronchi, and these again near cavities as large as ordinary vomicæ, surrounded by fibroid bands, emphysematous lobules, and lastly, pleuritic thickenings, we should not be surprised if we meet simultaneously noises belonging to each of these conditions, interspersed with certain areas in which we would find diminution or absence of all sound, whether normal or adventitious. This is the case to such an extent that a differential diagnosis, based upon physical signs alone, is not to be trusted.

TREATMENT.—One of the first indications in the treatment of any chronic discharge from a mucous membrane is to disinfect it, for experience proves that in so doing we remove a leading cause of the inveteracy of the complaint, viz., local irritation of the membrane by its own perverted secretion. It has been pithily said that it is no business of a mucous membrane to secrete mucus, but rather only an aqueous, slightly saline fluid, with but a trace of mucus to diffuse it equally over the surface. The presence of a layer of mucus, therefore, is a sure sign of something wrong, and we may add that the longer that layer is allowed to remain, the more it acts as an irritant by its fermentative operation upon the subjacent membrane. In practice, there can be no doubt that the sooner mucus is removed the sooner will an inflamed membrane recover, as we see illustrated by washing the bladder in cystitis. But washing is only a mode of disinfection, and hence illustrates the same general principle. In the alimentary canal, the natural gastro-intestinal secretions are each strongly antiseptic, and therefore the presence of a gastric or of an intestinal catarrh is evidence of the absence of those preservative, as well as digestive, juices. The best remedy for catarrhs of that mucous membrane, therefore, is the restoration of those secretions. On the other hand, where those secretions cannot reach, as in chronic dysentery, I have repeatedly succeeded in arresting, without any internal medication, the muco-purulent discharge from old rectal ulcers, simply by ordering the rectum to be thoroughly washed out after each passage by an enema of hot water, made disinfectant by the addition of twenty drops of the oil of peppermint.

I refer thus generally to the subject only to emphasize the more that prime indication in managing so intractable a disorder as chronic bronchitis, for next to the lesser exposure of the skin to chill, it is plain that the mitigation of a bronchitis during the summer season is owing to the fact that the patients are at that time able to inhale the open air so much more continuously than when they are jealously housed in winter. The open air is "bland," not because it contains some soothing ingredient characteristic of a given locality, but simply because the oxygen which it contains, is the natural disinfectant for the re-

spiratory passages. The best, indeed the only *curative* prescription for a settled case of chronic bronchitis is a place where the patient may spend two or more years in continuous out-door life, preferably in a tent, and sleeping in a hammock, because all catarrh will cease when the air-tubes have become thoroughly disinfected. The choice of climate, therefore, is not to be regulated by its heat or its moisture, or the reverse, but rather by the number of days in which it is comfortable to remain out-doors without exposure to chill.

Another prime indication subserved by open-air life is the toning-up of the weakened bronchial muscles and of the heart. Throughout the whole animal kingdom, the muscular power is directly proportioned to the activity of the respiration, that is, to the amount of oxygen taken into the system. It is the wonderful breathing capacity of insects which explains their wonderful muscular energy, and so soon as muscular tissue begins to weaken, or is prone to fatty degeneration, the greater is the need to afford it the freest supply of oxygen. This principle, therefore, illustrates the clinical fact that one of the most efficacious remedies in chronic bronchitis, and especially in the bronchorrhœa of the aged who have enfeebled hearts, is iron. As the only rôle of iron in the system is to carry oxygen, so I have been accustomed to prescribe the tincture of the chloride of iron, with excess of hydrochloric acid, in every case of heart disease, and of chronic bronchitis, as a prophylactic against dilatation or muscle failure, with the result of greatly diminishing the expectoration in the bronchial trouble, and enabling the patients to sleep much more continuously at night. In distinction from its effects in phthisis, iron is always well borne in chronic bronchitis, partly, no doubt, from the more febrile character of the former disease. As adjuvants to iron, we may recommend the ethers, such as the compound spirit of ether, the spirit of nitrous ether, dulc., and, in cases in which there is cardiac complication, digitalis.

A certain class of remedies may also be chosen for their antiseptic powers, such as the balsams and terebinthinates, like copaiba, buchu, tolu, etc. The objection to them, however, is that they are apt to disorder the stomach, and hence can be employed, advantageously, only now and then, especially on some exacerbation of the chronic disease with pain and increased coughing. Carbolic acid itself, made up into pills and taken in doses of about twelve grains a day, is more effective and better borne. A drink composed of twelve grains of carbolic acid and half an ounce of paregoric in a pint of water, to be taken through the day, is a frequent prescription when the cough is severe and the expectoration at all offensive. On the same principle we would recommend the daily use of inhalations of carbolized steam, described in the article on Asthma. The use of quinine, also as an antiseptic, in moderate daily dose, however, is to be recommended on general principles, particularly when there is free secretion of pus. The nitric acid, in combination with the iodide of potassium, is sometimes of great service in profuse expectoration, especially when there is reason to diagnose the presence of sacculated bronchial cavities. In some of these cases the oxide of zinc, with belladonna, has seemed to diminish secretion, as it does in phthisical cavities with profuse expectoration.

In those cases in which the expectoration is very viscid, and the cough correspondingly severe, I have found no remedy equal to the emulsion of linseed-oil, already referred to. It soon renders the sputa less tenacious, and similarly lessens the violent coughing, while it seems to promote a restoration to a more healthy circulation by lessening the congestive tumefaction through the specific action of oils on such conditions in mucous membranes. The aid of chloral and morphia is also valuable here, in checking the irritability of the bronchial nerves. In this class of cases a good deal of benefit may be derived from a prolonged course of mineral waters; those containing the largest proportion of common salt are to be preferred. Such a course is also to be recommended in those cases, above described, of lithæmic or of gouty tendencies, and in the bronchitis of chronic alcoholism. If there be much asthmatic wheezing, the administration of iodide of potassium with belladonna, and occasionally a course of arsenic, will prove of service. In all cases of difficult expectoration, it is well to rememeber the help which may be obtained from sipping hot drinks. A cup of hot coffee taken thus, before rising in the morning, may enable a patient to rid himself of an accumulation of mucus which otherwise would be voided only by repeated and exhausting efforts.

The importance of protecting the skin of persons affected with bronchitis, in such a climate as ours, cannot be overrated. They should be dressed in buckskin underwear from head to foot throughout the whole autumn, winter, and spring months. The suit should be worn over a light flannel, which may be changed to thicker material in mid-winter. All chest protectors should be discarded because they are altogether inadequate for a condition in which a chill to any part of the surface, and especially to the feet, is quite enough to set up a fresh access of inflammation. When such exacerbations occur, one of the best measures is to resort to free diaphoresis by the hot-water and blanket pack. The patient should go to bed and undergo this thoroughly, three or more times a day, and by so doing he may effectually cut short a severe visitation of his enemy. During the summer, it is very desirable that the patient take daily cold salt-water sponge-baths, followed by active friction. This measure certainly lessens the tendency to catching cold, and the same may be said of the use of oil inunctions for the whole body, to be practised every morning in the winter, with the precaution of exposing the body only in a warm room.

The treatment of acute diffuse bronchitis, supervening upon the chronic form of the disease, belongs more properly to the subject of broncho-pneumonia.

William H. Thomson.

BROOM (*Scoparius*, U. S. Ph.; *Scoparii Cacumina*, Br. Ph.), *Cytisus Scoparius* Link. (*Sarothamnus Scoparius* Koch, *Genista Scoparia* Lamk.); Order, *Leguminosæ*, *Papilionaceæ*. It is a well-known European shrub, occasionally cultivated here for ornament. It grows from half a metre to one and a half metres high (twenty to sixty inches); has numerous slender, upright branches; rather few small leaves; large, bright yellow flowers. The lower leaves are ternate, with obovate, hairy leaflets, the upper often reduced to a single blade. The flowers are solitary, or two or three together, and have a broad, two-lipped, persistent calyx; a fine, showy, papilionaceous corolla, with a long style rolled upon itself like a bugle. The fruit is a flat, hairy, many-sided legume. This plant is abundant in sandy and waste places in England and Central Europe, growing in large clumps, or colonies, and also extends eastward into Russia and part of Asia. It has been known as a medicine for several hundred years.

The part gathered for medicinal use is the branches, although the whole plant is active. These are long and wand-like, sharply five-angled, not very leafy, of a green color when fresh, but becoming very dark upon drying. They are tough, nearly smooth, odorless, and very bitter. The flowers are occasionally used; they also become brown by drying.

Broom contains two interesting principles, discovered by Stenhouse, in 1851;—*sparteine* is a colorless, thick, oily, liquid alkaloid, having a peculiar odor and an exceedingly bitter taste. It is only slightly soluble in water, although it holds, itself, a little water in solution. Its salts are usually solid, but not crystalline. With care and protection from the air sparteine may be distilled without change, but upon exposure to the atmosphere it quickly becomes brown and opalescent. It is an active paralyzing and narcotic poison. Plants grown in the shade are said to be especially rich in it. The yield is only about one-half of one thousandth part. The other constituent, *scoparin*, is solid, either colloid or crystalline, in pale yellow tufts or scales, easily soluble in hot water and alcohol, but sparingly so in cold water. Its solutions are greenish. This is considered to be the diuretic element of Broom.

Broom is a well-established "hydragogue" diuretic, and indicated in general œdema, from various causes; in full doses it usually also acts as a cathartic, which is an added advantage. Very large doses may produce alarming purging and vomiting. Dose, two grammes (2 Gm. = gr. xxx.), frequently repeated until some effect is obtained. A decoction is a suitable form for administration. *Scoparin* has also been given, but not sufficiently to establish its value. Dose, one to three decigrammes (0.1 to 0.3 = gr. jss. ad v.) once or twice a day.

Allied Plants.—A number of poisonous plants of similar qualities to those of Broom belong to neighboring genera. Dyer's Broom (*Genista tinctoria* Linn.), whose flowers are used for their yellow color, was formerly given for the same purpose as Broom. The beautiful Laburnum (*Cytisus Laburnum* Linn.) occasions vomiting, purging, and coma when taken, and contains a poisonous alkaloid, *Cytisine*. The Lupins are generally harmless, and several species are used as food plants, but others are bitter and contain alkaloids. For a list of useful or interesting *Leguminosæ*, see Senna.

Allied Drugs.—*Conine* and *Nicotine* are brought to mind by the alkaloid Sparteine; but this, though the most active, is not probably the most useful principle in Broom. Digitalis and Squill as diuretics, Elaterium, Colocynth, and Senna as cathartics, are used in similar cases to those in which Broom is indicated. *W. P. Bolles.*

BROWNSVILLE. The accompanying chart, representing the climate of the city of Brownsville, Tex., and obtained from the Chief Signal Office in Washington, is here inserted for convenience of reference. A detailed explanation of this and of other similar charts will be found under the heading Climate; where also the reader may find suggestions as to the method of using these charts. *H. R.*

Climate of Brownsville, Tex.—Latitude 25° 53′, *Longitude* 97° 26′.—*Period of Observations, July* 1, 1876, *to December* 31, 1883.—*Elevation of Place of Observation above the Sea-level*, 28 *Feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	54.7	66.0	57.9	59.5	70.8	50.8	66.9	49.7	83.0	77.0	44.0	18.0	25	28
February...	57.6	68.9	60.4	62.3	69.0	58.8	71.4	53.8	85.0	74.0	43.0	27.0	17	20
March......	64.2	75.4	67.4	69.0	71.2	67.5	77.2	60.8	92.0	83.0	48.0	35.0	20	24
April.......	70.4	81.0	72.9	74.7	75.8	74.0	83.3	66.4	97.0	88.0	57.7	43.0	14	20
May........	76.1	85.4	77.5	79.6	81.1	78.3	87.5	71.7	99.0	90.0	66.0	49.0	21	23
June.......	79.9	89.2	81.5	83.5	85.5	81.8	91.2	75.8	102.0	92.0	73.0	63.0	16	22
July	81.0	90.0	82.4	84.4	87.8	83.0	92.0	76.8	98.0	94.5	73.0	68.0	23	25
August.....	79.2	89.4	81.4	83.3	87.8	80.5	93.4	75.1	101.0	92.0	72.0	69.0	25	26
September..	74.9	85.8	78.0	79.5	82.1	77.7	88.4	71.7	96.0	92.0	64.0	57.0	21	22
October	71.3	82.1	74.2	75.8	78.6	70.4	84.0	67.9	95.0	86.0	65.0	49.0	23	26
November..	60.8	71.3	64.1	65.4	70.0	56.3	73.9	57.3	89.0	84.0	51.0	30.0	26	26
December..	55.9	66.5	59.0	60.4	66.7	55.2	69.2	52.8	83.0	78.0	47.0	18.0	23	23
Spring......	......	......	......	74.4	75.8	73.5	......	......	......	......	......	......	......	......
Summer....	......	......	......	83.7	84.2	82.3	......	......	......	......	......	......	......	......
Autumn....	......	......	......	73.5	75.5	68.9	......	......	......	......	......	......	......	......
Winter	......	......	......	60.7	66.2	56.8	......	......	......	......	......	......	......	......
Year........	......	......	......	73.1	73.8	72.5	......	......	......	......	......	......	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind.*
						Inches.	From	Miles.
January....	65.0	79.6	8.1	8.1	16.2	2.10	N.	7.0
February ..	58.0	78.9	8.0	7.2	15.2	1.90	N. & S.	8.2
March	57.0	78.3	10.4	7.6	18.0	1.36	S.E.	8.2
April.......	54.0	75.0	13.7	6.4	20.1	0.66	S.E.	8.9
May........	50.0	75.2	15.6	9.3	24.9	2.66	S.E.	7.6
June.......	39.0	72.6	12.7	13.7	26.4	1.74	S.E.	7.3
July	30.0	71.9	14.2	13.3	27.5	2.63	S.E.	6.9
August	32.0	73.2	16.1	9.9	26.0	5.37	S.E.	5.0
September.	39.0	76.7	12.6	11.8	24.4	5.47	S.E.	4.3
October....	46.0	76.0	13.6	12.9	26.5	3.31	S.	5.2
November.	59.0	77.8	12.0	8.5	20.5	2.42	N.	6.9
December .	65.0	80.2	11.9	7.6	19.5	2.41	N.	7.0
Spring.....	64.0	76.2	39.7	28.3	63.0	4.68	S.E.	8.2
Summer...	39.0	72.6	43.0	36.9	79.9	9.74	S.E.	6.4
Autumn ...	66.0	76.8	38.2	33.2	71.4	11.20	N.	5.5
Winter.....	67.0	79.6	28.0	22.9	50.9	6.41	N.	7.4
Year.......	84.0	76.3	148.9	116.3	265.2	32.03	S.E.	6.9

* Miles per hour.

BRUCIA, TOXICOLOGY OF. Brucia is an alkaloid associated with strychnia in the seeds of the genus *Strychnos*. In chemical composition the alkaloids are allied, and statements have been published of the conversion of one into the other by laboratory manipulation. Poisoning by brucia is rare, and the doses by which dangerous symptoms are caused are much larger than those of strychnia. The symptoms of poisoning, in fatal cases, have closely resembled those by strychnia, and the two are generally regarded as differing only in degree. It appears, however, from some very recent investigations that the effects generally observed in brucia-poisoning are due to the impurity of the alkaloid, by the presence of strychnia, the entire separation being a difficult operation. Dr. Thos. J. Mays, of Philadelphia, in a paper contributed to the *Therapeutical Gazette* for June, 1885, has recorded some interesting observations with brucia, both in the ordinary and pure form. He points out that all common samples show strychnia effects, which are entirely wanting when the absolutely pure alkaloid is used. Dr. Mays has shown that in frogs the first effect is a motor paralysis, followed by convulsions and hyperæsthesia. Locally applied, it has a benumbing action on the skin analogous to cocaine, but not so prompt, probably due to slower absorbability. A ten per cent. solution will relieve the pain of toothache, and the scalding of the tongue caused by Cayenne pepper. Applied on the skin, it will cause marked diminution of sensibility. Its analogy to cocaine thus becomes very striking. The commercial article is, however, entirely unfit for such use; nothing but an absolutely pure brucia should be employed.

It is obvious from these considerations that it would not be worth while to give a summary of the symptoms, treatment, etc., of brucia-poisoning as recorded from the

observed cases, as they are doubtless merely cases of poisoning by strychnia complicated by the effects of brucia.

Henry Leffmann.

BRYONY (*Bryonia,* U. S. Ph.; *Bryone blanche,* Codex Med.), *Bryonia alba* Linn., and *Bryonia dioica* Linn.; Order, *Cucurbitaceæ.* The Bryonys differ from the Cucurbitas (Pumpkins, etc.) principally in their simple stamens, usually diœcious and clustered flowers, and smaller fruits. The species under consideration are perennial herbs, with thick, fleshy, turnip-like roots, succulent, climbing stems, and five-angled or lobed leaves.

The flowers are small, dirty-white, in small clusters; stamens five—four in two pairs, one odd. The fruit is a small, spherical, three-celled, indehiscent berry. Seeds rather few, not margined like those of the pumpkin. *B. alba* has monœcious flowers, smooth roots, and black fruits. *B. dioica* has diœcious flowers, rough, warty roots, and scarlet berries. They are inhabitants of Europe, Northern Africa, and the Orient; *B. alba* is more common in the east, *B. dioica* in the west of Europe. The root is thick, spindle-shaped (often as large as the arm), fleshy, branched, pale brown externally, white and containing milky juice within. It is gathered in the spring, and prepared for use by being cut transversely

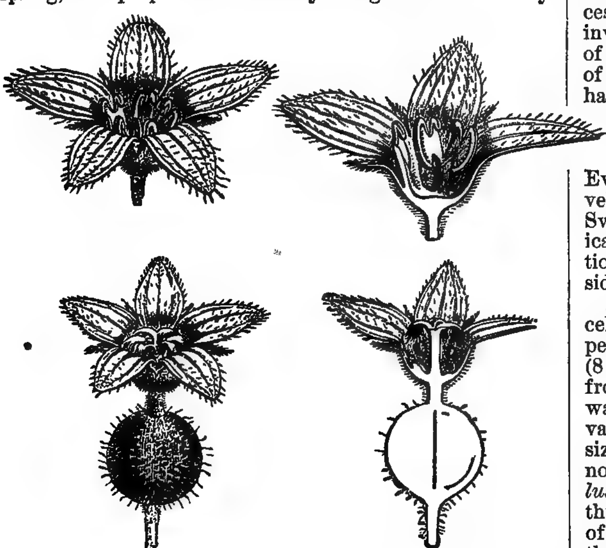

FIG. 527.—Bryony (*B. dioica*), Staminate and Pistillate Flowers with Sections. (Baillon.)

into slices and dried. These are from three to six centimetres in diameter, with a light gray-brown, wrinkled bark, and a dirty grayish or yellowish-white section; upon the latter concentric rings of woody bundles and radiating medullary rays may be seen. The taste is disagreeably bitter, odor none. Bryony contains a peculiar, bitter glucoside, *bryonin,* a colorless, amorphous powder soluble in water and alcohol. Treated in the usual way with dilute acids, it splits into sugar, bryoretin and hydrobryoretin. This decomposition is said to already have taken place in part of the bryonin of the dried root.

ACTION.—Bryony is an active and harsh cathartic of the colocynth and elaterium type. In large doses it is apt to induce also vomiting, and may cause inflammation of the stomach and intestine. Death has followed its medical use. Bryonin has the same action as the root.

The dose of Bryony (the dried root) is given as from one to four grammes (1 to 4 Gm. = gr. xv. ad ʒ j.) once or twice a day; the smaller dose should be first tried. There is a Tincture (*Tinctura Bryoniæ,* U. S. Ph.), strength, one-tenth, in which form it may be given, although probably no better than the powdered root. *Bryonin* is to be preferred; dose, one decigramme.

ALLIED PLANTS, ALLIED DRUGS.—See COLOCYNTH.

W. P. Bolles.

BUBO (from βουβαν, the groin; Ger., *Leistenbeule;* Fr., *bubon*), a term originally used by medical writers of antiquity to designate glandular tumors of the groin, was applied by authors of the period of the Reformation to glandular inflammations of every part of the body irrespective of their nature. Modern writers have again reserved the term for inflammatory affections of the lymphatic glands of the groin. While buboes are alluded to in the earliest medical treatises of which we have any knowledge, and the pathogenetic importance of the genitalia in their causation was apparently familiar even to Hippocrates, the distinctive types of the affection which are now generally recognized were, of course, unknown until long after the general outbreak of syphilis, which appeared at the close of the fifteenth century. Then, besides the adenitis, which suppurates and often leaves an ulcer, there presented itself a bubo which from its inception is indolent, unattended by pain, and rarely the seat of suppurative change. Gaspard Torella, Fallopius, Nicolaus Massa, Paracelsus, and other writers of that memorable epoch in the history of venereal diseases speedily recognized and described with sufficient accuracy this earliest systemic manifestation of syphilis. Nevertheless, the nature of buboes was so little comprehended that they were regarded as sympathetic in character, or as unsuccessful endeavors of nature to check through them the invasion of the system by the disease. That the majority of buboes result from the deposit in the lymphatic glands of a poison conveyed to them from a distance could not have been known prior to the discovery in 1651, by Oläus Rudbeck, of lymphatic vessels in different parts of the body, and with a function of absorption like that of the lacteals previously described by Asseli. Even then precise knowledge of the subject was slowly developed, and it remained for the observations of Hunter, Swediaur, Benjamin Bell, and Ricord to depict the clinical symptoms and finally establish the etiological relations of the different varieties of the disease under consideration.

ANATOMICAL AND PATHOLOGICAL.—The subcutaneous cellular tissue of the groin encloses, together with the superficial blood and lymphatic vessels, a varying number (8 to 12) of lymphatic glands, which receive their lymph from the subumbilical segment of the anterior abdominal wall, from the external genitalia, urethra, perineum, vagina, cervix uteri, anus, and inferior extremity. The size of the inguinal, as of other lymphatic glands in their normal state, is so small that in persons with a *panniculus adiposus* of ordinary thickness they cannot be felt through the skin. Oval or elongated in form, the glands of the groin are arranged in two quite distinct groups, the larger of which follows the course of Poupart's ligament, while the smaller forms part of the cribriform fascia covering the saphenous opening. The individual glands of these groups, when naturally large or enlarged from disease, present distinctive directions. Those which overlie the ligament have their axes parallel to the inguinal fold, while those of the lower group have their axes parallel to that of the lower extremity. This factor is of considerable importance, in that it often gives a clue to the source of the ganglionic complication, since the lymph from the external genitalia is conveyed to the upper, while that from the lower extremity passes to the lower chain. It must not be forgotten, however, that these groups communicate very freely with each other by numerous lymphatic vessels, in which the circulation is from the upper to the lower glands. Indeed, it is through the glands over the saphenous orifice and through one or two glands (Rosenmüller's), deeply seated underneath the *fascia lata,* that the lymph must pass from both lower extremity and genital area before it can enter the general lymph-receptacle in the abdomen. This anatomical factor will account for the not very infrequent occurrence of two suppurating glands on the same side of the body, of which one belongs to the upper and the other to the lower chain, the inguinal fold lying between them.

Formed of a capsule embedded in the periglandular adipose tissue, containing within it lymph-sinuses, networks of reticular connective-tissue and lymph-cells, the

lymphatic gland, when the seat of inflammatory changes, presents appearances which vary greatly with the degree of the inflammatory process and the nature of the primary cause. The acute adenitis which may follow in the wake of any traumatic or specific ulcer of the skin or mucous membrane, and which manifests itself clinically by moderate swelling and tenderness of the affected gland, is associated with dilatation of its blood-vessels and proliferation of the lymph-corpuscles contained in the meshes of the reticular network or stroma.[1] When this cellular infiltration becomes excessive the reticular network suffers from compression; it becomes rarefied; the capillaries are obstructed or completely torn. When deprived of their nutrition the infiltrating cell-masses are speedily converted into pus foci. Through the confluence of these the gland-capsule, already distended from the inception of the process, becomes an irritant to the surrounding parts; the subcutaneous cellular layer and the skin more or less rapidly participate in the morbid changes, and soon the suppurating bubo, having attained twenty-fold the size of the normal gland, is emptied spontaneously or by the knife of the surgeon. After the evacuation of the pus the abscess-cavity speedily contracts, and cicatrization ensues with such rapidity, at times, that the wound is closed in a week from the opening of the bubo. Not always does this process of repair follow so quickly the elimination of the pus. The behavior of the periglandular tissue is a most important factor in the events that are to follow. This is often the seat of more extensive inflammation than the gland itself. Minute abscesses form around the inflamed gland from obstruction of its afferent vessels, so that after the elimination from the gland itself this remains embedded in a secondary abscess-cavity formed about it. Covered by granulations, it may in time appear as a foreign body in the floor of an ulcer, or it may remain for months covered by integument yet surrounded by indolent sinuses. Nor is the pathological process that ends in suppuration necessarily limited to one gland alone. The morbific matter may be conveyed from the gland originally involved to one or more in the vicinity, until a number of them are bound together in one large inflammatory nidus, the suppuration of which usually entails the destruction of a considerable extent of skin. To a large extent, the termination of an adenitis depends upon the nature and gravity of the primary disease. If the irritation in the lymph-radicles of the affected gland is mild or evanescent, as in herpes, balanitis, erysipelas, or gonorrhœa, the consecutive adenitis rarely proceeds to suppuration. Absorption of the infiltrating cellular elements may supervene in a few days, or even hours. On the other hand, long continuance of the local irritation, whatever its character, will at times completely change the results of the glandular inflammation in that the cellular infiltration, being insufficient in extent to induce suppuration, yet not disappearing by absorption, leads to organization. Here it is not the exuded lymph-corpuscles that are converted into a durable tissue, but the reticular substance which forms the framework of the gland. In the suppurating adenitis this disappears, in subacute adenitis, it undergoes a reactive hypertrophy. In the course of time the septa of the gland increase so greatly in thickness that the lymph-corpuscles between them are seriously encroached upon. Hence the firm fibrous appearance of the section of a lymphatic gland that has been the seat of a chronic inflammation.

Etiology and Varieties.—The inguinal glands differ in no way from those of other parts of the body, and the morbid processes to which they are subjected can be duplicated in those of the groin. Hence *a priori* reasoning as to the venereal origin (using the term in its widest significance) of an adenitis here situated must be strenuously deprecated. Violent exercise, strains while lifting, or mounting a horse, direct trauma, herpes, furuncles, eczema genitalium, and scabies may all be the source of an inguinal adenitis. Only a short time ago there appeared at my clinic a lad of seven years, with two suppurating glands, the one above, the other below the ligament. The most careful inspection of genitalia and lower extremity failed to reveal anything abnormal. The cervical glands were not enlarged, nor were there other traces of a strumous habit discernible. The only adducible cause of the bubo was a severe fall from a sand-bank, which the boy had sustained one week before aggravated symptoms supervened. Buboes, such as these, which in no way depend upon an inoculable primary disease, and which stand neither immediately nor remotely in connection with the sexual act, I have been in the habit of designating *non-venereal buboes.*

Each of the three typical venereal affections, viz., gonorrhœa, the chancroid, and the initial lesion of syphilis, may be attended by complications of the inguinal glands, which are known as *venereal buboes*, and are subdivided into, 1, the simple or inflammatory; 2, the virulent, and 3, the syphilitic varieties. They are produced respectively (1) by the irritation of a gonorrhœa and chancroidal or syphilitic ulcer; (2) by the chancroid solely, and (3) by the presence of the initial lesion alone.

1. Buboes are rarely produced by gonorrhœa. While a slight tenderness of the neighboring glands not infrequently attends a urethral discharge, it is very exceptional to witness in them an inflammation that ends in suppuration. Yet buboes of considerable size, with extensive destruction of tissue, are occasionally encountered as complications of gonorrhœa. They have been met mostly in very young subjects, in persons of strumous habit, or in subjects debilitated by a previous attack of syphilis. Again, it is not unusual to find a chronic hyperplasia of one or more of the inguinal glands after repeated and prolonged urethral discharges, a condition analogous to that of the cervical glands in persons prone to catarrhal affections of the throat. The term "sympathetic bubo," formerly applied by preference to gland-complications of gonorrhœa, is gradually being discarded. Whether the bubo results from purulent preputial catarrh, gonorrhœa, or chancroid, instances are not rare in which there can be detected that cord-like swelling along the dorsum of the penis, which is but the evidence of a lymphangitis developed by direct propagation of the disease from its first seat. Still, the morbid process in the lymphatic vessels does not usually manifest itself by perceptible symptoms. Like the *vas deferens* in epididymitis, the lymphatic vessel conveys the irritant to the gland without being often seriously affected by it.

2. The chancroid is by far the most common precursor of the bubo. From its very inception to the period of its repair, and even for months after its complete closure, the chancroid may be the cause of an inflammatory bubo. This the soft sore may accomplish in its dual position of a local irritant, and of an ulcer producing an auto-inoculable virus. Ricord has formulated the law that when the chancroidal virus is absorbed into a lymphatic gland there must inevitably be a suppurating bubo, the pus from which, in turn, will reproduce a chancroid. When the pus from a bubo of chancroidal origin is not inoculable, it is presumed that the fluid absorbed from the chancroid did not possess the characteristic qualities of chancroidal virus. This is the distinguishing feature between the simple and virulent buboes originating in chancroids. Still, it is difficult to comprehend why a large suppurating, yet non-purulent bubo should follow from the irritation of so small an area as is usually covered by a chancroid, when it so rarely follows the infinitely more extensive irritation of the urethra from gonorrhœa. It has been estimated that the proportion of simple to virulent buboes (following chancroids) is nearly equal; it being 149 simple to 138 virulent.[2] These figures are far from conclusive, since every case should be made the subject of most careful inoculation before being utilized in statistics. The relative frequency of buboes in general as a complication of chancroids has been more accurately determined. Fournier[3] has observed 207 chancroids of which 65 were complicated by suppurating buboes.

In 146 cases of chancroid observed at my dispensary in the Medical College of Ohio, during a period of two years, suppurating buboes were recorded in 40. Thus it appears that in about twenty-eight per cent. of the total number of chancroids buboes appear. It is a remarkable fact that in women buboes are not so prone to develop as

in men, owing, probably, to the fact that the latter cannot abstain from work for a trivial soft chancre. The size of the original sore does not appear to influence, in any manner, the action of the inguinal glands, since it is not unusual to find destructive buboes following small and superficial ulcers, while destructive chancroids remain uncomplicated. The retention of the discharge from the chancroid is, no doubt, an important element in the production of buboes, since those of the frænum, and those associated with phimosis, are relatively most often followed by them. With few exceptions the chancroidal bubo develops in the groin of the same side occupied by the first sore. When this is situated in the median line, and particularly when it involves the frænum, bilateral buboes are apt to supervene. Only in very exceptional cases is the irritation or virus conveyed across the median line, to the glands of the opposite side, through the anastomosis of the lymphatic vessels. Occasionally a bubo will form in the median line at the root of the penis, or in the pubic region, where a small lymphatic gland is often found at the confluence of the lymphatic vessels of the two sides. Pubic buboes were encountered in 3 out of 298 cases.[4]

3. Syphilis. The initial lesion of syphilis is almost invariably followed by a sclerosis of the upper chain of the inguinal lymphatic glands, of which the innermost is first involved during the first fortnight after the primary sore manifests itself. In the course of a few weeks the other glands of this region (*Pleiades ganglionnaires*), and subsequently the glands in general, become affected. Fournier failed to find induration of the inguinal lymphatics 5 times in 265 cases; Berkeley Hill[5] 3 times in 176 cases, whereas Bumstead[6] has never "met with a chancre which was not attended by induration of the neighboring lymphatic ganglia." It is a characteristic of the syphilitic bubo that it involves the entire chain of lymphatic glands, and that its progress is not attended by acute symptoms. Hence this form of bubo is often termed *indolent*. In its morbid anatomy nothing of an inflammatory nature is apparent. The small-celled infiltration which takes place in the initial lesion of syphilis is reproduced in the inguinal glands. Every mesh of the reticulum is fully distended by cells. The induration resulting therefrom continues for months, and even for years, without terminating in inflammation or necrosis of the gland. As in the case of the primary induration, after continuing for a varying length of time, a fatty metamorphosis of the cells ensues; the detritus is absorbed, and the gland returns to its normal condition (Rindfleisch).[7] In galloping syphilis and in that of lymphatic subjects, the inguinal glands at times undergo extensive suppuration. Even then it will be found that the immediate cause of the inflammation is an unusual irritation of the primary ulcer, or the development in it of phagedæna or of diphtheritic deposit. This suppuration of an indolent bubo, therefore, has neither a favorable nor contrary influence on the subsequent course of the syphilis. While the suppurating adenitis is, as a rule, a sequel of the soft chancre, its presence does not infallibly demonstrate the non-infecting (chancroidal) character of the primary sore.

Bubon d'Emblée.—The buboes which have been thus far considered are ascribable to plainly discernible lesions in the area of origin of the lymphatic radicles of the affected gland. Therefore they are secondary in character. The question has for a long time been discussed, whether, without the development of a lesion at the point where the virus entered the body, this could be directly absorbed and conveyed to the glands and produce in them its peculiar pathological effects. Authorities of great weight (Vidal, Reynaud, Benjamin Bell) have cited numerous instances in which such absorption without local reaction is supposed to have taken place. To designate this particular form of ganglionic disease the terms "primary bubo," "idiopathic bubo," and "bubon d'emblée," have been used as synonyms. It has already been observed that primary buboes could arise from direct trauma, excessive exercise, strumous habit, and other like causes. Aside from these etiological factors, it is at present deemed impossible for a venereal bubo to develop without pre-existing primary trouble. It is within the experience of every one that this primary affection may be very trivial in extent and of remarkably short duration, therefore escaping the attention of the patient. Here, as in the case of the minute dissecting-wound that may lead to suppurating lymphadenitis, and even to death, the original lesion, or some trace of it, can always be found. Until it can be demonstrated that chancroidal pus or syphilitic virus can be made to permeate the unbroken skin, there is no good cause for believing in the bubon d'emblée. It is particularly through the efforts of Ricord, Langlebert, Fournier, and others that the "idiopathic bubo," for so long a period the subject of most ardent polemics, is now generally believed to have no actual existence.

Symptomatology.—*Simple Bubo.*—The appearance of an inguinal bubo is ordinarily announced by a feeling of discomfort while walking. A passing sense of fulness causes the patient to examine the part, when he finds one or more tender glands in the groin. Palpation, at this time, reveals the presence of a resistant movable swelling, tender to the touch, and varying in size from a bean to a cherry. Within a few days the symptoms rapidly increase in severity. The tumefaction, increasing in extent, is oblong in form with the long axis parallel to the groin when a gland of the upper chain is affected, and parallel to the axis of the thigh when one of the lower group is involved. A decided elevation of the skin becomes apparent before its implication in the process occurs. Pain is usually complained of, and it is either sharp and spasmodic in character, or dull and constant. Hence follow disturbed sleep and impeded progression. With the extension of the inflammation to the periglandular tissue, the mobility of the swelling disappears, the tumor loses its well-defined outline, the skin itself becomes adherent, and the seat of more or less redness. Even when symptoms so pronounced as these have continued for a week or more, resolution may supervene in the course of two or three days. Such a fortunate termination is more likely to ensue when the primary affection was a gonorrhœa, balano-posthitis, or herpes. But in undoubted cases of chancroid, a gradual resolution of the acute inflammation, or its termination in a chronic induration, is not at all infrequently observed. These terminations are quite as likely to follow in the buboes which supervene during the early stages of the chancroid, as in those that attend the reparative process of the sore or that follow its cicatrization.

When the inflammation passes to the suppurative stage the indurated mass generally presents a softer spot, which is as often situated out of, as in the centre of the swelling. With the increase of the area of softening the skin changes to a dusky hue. An examination, while the skin is still intact, reveals distinct fluctuation, and when the attenuated integument is indented by the finger the indurated wall of the abscess can ordinarily be distinguished. It is at this time, from ten days to two weeks after the beginning of the bubo, that the pus is usually evacuated by incision. In quantity this does not often exceed an ounce. If left to itself, weeks will often elapse before the skin yields to the ulcerative process, during which time the abscess increases in its dimensions until it contains at times from four to six ounces of thick, creamy pus. When permitted to open spontaneously, the abscess usually opens at one point only, although two or three apertures are often formed. This feature of inguinal suppurating buboes requires especial mention. When the swelling has attained the size of a walnut or small peach, it will often appear to be subdivided by a deep furrow into two quite distinct growths, of which the smaller is usually situated below and nearer the median line. When suppuration is finally established, a separate opening will be formed or made necessary for each division of the swelling, irrespective of the question as to whether more than one gland is involved. Not always does the suppurating bubo run so acute a course. Instances are not at all infrequent in which the inflammatory symptoms develop in successive stages with intervals of quiescence. Such buboes often require several months before maturing, and for these cases the term "subacute" is occasionally re-

served. The pus contained in them is usually watery in character, and ordinarily not very abundant.

The clinical course of a simple bubo, after it has discharged, does not differ materially from that of an abscess from other causes. In about thirty per cent. of all cases, and particularly in those in which an early incision was made, the walls of the abscess become agglutinated, and suppuration rapidly ceases. Generally, however, the discharge continues from one week to many months before the abscess cavity is obliterated. Chronicity of discharge characterizes particularly those abscesses in which more openings than one have formed, and in which sinuses lined with exuberant granulations undermine the skin. In many of these cases, the force of the inflammation having been spent on the periglandular tissue, these sinuses lead down to one or more glands. When the integument covering the sinuses finally yields to the suppurative process, or is divided by the knife, the gland covered by granulations will appear in the floor of the ulcer or in the wound thus produced.

Virulent Bubo.—It has already been observed that when the virulent element of the chancroid is deposited in a lymphatic gland, suppuration in the latter is inevitable. The bubo of absorption, which results from this, in its inception, presents symptoms precisely like those that belong to the simple bubo. The rapidity of development of the symptoms alone might arouse suspicions as to the virulent form of adenitis. It is only after the evacuation of the abscess that the differential diagnosis becomes practicable. Inoculation with the pus of the virulent bubo invariably produces a chancroid; inoculation with the pus from a simple bubo yields negative results save in syphilitic subjects. But the inoculation test is superfluous, since the progress of the virulent bubo after it is opened is usually sufficiently pronounced. The margins of the wound which gave passage to the pus become inoculated with the chancroidal virus. As in the chancroid, during its period of progress the integument covering the virulent bubo is rapidly destroyed until a true chancroidal ulcer, varying much in area and depth, presents itself in the groin. When fully exposed to view, the floor of the bubo, from absorption, presents the yellowish-gray, irregular, and worm-eaten appearance of the chancroid. The margin of the ulcer, tumefied, at one part, appears attenuated or undermined at another. From the entire surface there is exuded a watery pus which is often tinged with blood. Capillary hæmorrhages from the bubonic ulcer are often encountered as in the chancroid. Indeed, the clinical history which belongs to the chancroid is on a larger basis duplicated in the case of the bubo. Healing in rare instances in a few weeks, it, in less fortunate cases, continues in its destructive course for months, and occasionally even for years. When thus protracted, the ulceration usually assumes the serpiginous type, healing in one portion and extending in another. Thus the ulcer gradually spreads over abdomen, thigh, pubes, or gluteal region, leaving frequently ungainly cicatrices. In these cases the ulcerative action is often so sluggish that, as in lupus or rodent ulcer, it is almost imperceptible. Continuous auto-inoculation of the skin in the vicinity of the ulcer is the only plausible explanation of these protracted forms of bubo. Phagedæna, that most terrible complication of the venereal sore, occasionally attacks the virulent bubo. Under its influence the bubo may, in a few weeks, become converted into an ulcer the size of the palm. Superficial in some cases, in others the ulcer under its influence dips down into the tissues, producing extensive sloughs. Progressing among the blood-vessels, it has been known to open them and induce fatal hæmorrhage. Fatal results have likewise been induced by the excessiveness of discharge and from pyæmia.

Syphilitic Bubo.—The inguinal adenopathy of syphilis is but the reproduction on a larger scale of the indurating process manifested in the primary lesion. Appearing early and affecting an entire group of glands, the syphilitic adenopathy yields a row of larger and smaller tumors, freely movable and easily felt, except in very obese subjects. These tumors are hard, resistant, not tender to the touch, and usually largest on the side of the primary sore. Oftener than in the other forms of bubo, the dorsal lymphatics of the penis participate in the morbid process and appear in the form of indurated cords with irregular nodosities. Like the enlarged lymphatic glands, these lymphatic cords are freely movable. It has already been observed that indolence characterizes the syphilitic bubo. Only in persons of scrofulous taint, and in cases of great malignancy of the syphilitic virus (galloping syphilis), does suppuration ensue. With or without treatment, the syphilitic bubo continues while the primary and many of the secondary manifestations remain. It is rare to find these buboes subside completely, even under treatment, in less than two or three months, and in many instances they survive all other syphilitic lesions, when they assume great diagnostic importance in determining the presence or absence of a syphilitic taint. After continuing sometimes in an unaltered state for two or three years, they finally subside spontaneously.

Treatment.—The treatment of buboes must necessarily vary with the nature of the primary trouble. In a prophylactic way nothing can be done to prevent the syphilitic bubo, while much can be accomplished in the prevention of simple glandular inflammations as complications of the chancroid and gonorrhœa. In both these affections violent exercise and excessive walking and riding should be strictly interdicted. Irritant applications to the primary disease should be strictly avoided, since too astringent urethral injections and irritating ointments applied to chancroids are often the immediate causes of gland complications. What influence has the cauterization of the chancroid upon the development of buboes? If statistics be carefully examined, it will be found that in about thirty per cent. of all cases buboes supervene, and that their development is uninfluenced by the use of, or abstention from, cauterization. For this reason the application of violent caustics to chancroids is being more and more discarded. Of much greater importance as a prophylactic is cleanliness and the securing of a free escape for all discharges. It is for this reason that chancroids treated in private practice are much less often complicated by buboes (according to my experience, one to eight) than those of hospitals, and particularly of dispensaries.

When the evidences of an adenitis become unmistakable, every effort must be made to bring about resolution of the inflammation, since this favorable termination is possible in every instance save those in which the chancroidal virus has been observed. As in other inflammations, rest in bed is the chief antiphlogistic measure, and its importance must be fully explained to the patient. Applications of very cold cloths will, at this time, prove serviceable. A rubber bag is preferable, since it acts at the same time as a compressor. Local applications of the *liquor plumbi subacetatis*, with cold compresses, have been highly recommended by Hamilton and Zeissl, and are doubtless often beneficial. It is at this period of the inflammation that repeated applications of the *tincture of iodine* are so frequently resorted to. Although this practice has stood the test of time, and has the sanction of eminent authorities, it seems to me devoid of benefit, and often pernicious in its results, since it not infrequently is followed by violent inflammation of the skin and hair follicles, even to the extent of vesication. Another important objection to the tincture of iodine is the fact that the artificial condition of the skin produced by it frequently prevents the early detection of suppuration. Where, for the purposes of absorption, iodine seems indicated, I have lately employed the iodide of lead quite extensively, using in connection with it veratrin, belladonna, or opium, to allay pain. Since compression, where it is practicable, plays an important rôle in the treatment of inflammations, it should be used here. It can be best applied by means of a bag half-filled with small shot. If the patient cannot be retained in bed, collodion applications and a compress, held in position with a spica bandage, should be resorted to. Happily for the patients, a number of methods of aborting the inflammation which were formerly practised have been entirely abandoned. Among them may be mentioned methodical compression by instruments, repeated blistering with the subsequent

application of mercurials, the forcible rupture of the gland capsule, and the use of the seton. To these may be added the subcutaneous incision of the gland and the somewhat analogous procedure of Auspitz. The latter observer punctures the inflamed gland even before suppuration can be detected. A probe is introduced through the opening and the glandular septa are torn; the substance of the gland is thus broken up and discharges through the external wound. This practice of Auspitz has not found and does not deserve many followers. Nevertheless, it has been most highly endorsed by Bumstead.

When suppuration has been established, the treatment of the bubo must not vary from that of abscesses in other easily accessible portions of the body. *Ubi pus, ubi incisio* is a rule that should be adhered to in the disease under consideration. The ways in which the pus is to be evacuated are numerous. Within the last fifteen years aspiration has often been resorted to, and has been highly recommended by a number of French and German observers. Where it is evident that the purulent accumulation is small, and that a suppurative periadenitis has not yet developed, aspiration cannot be too often practised. Attended by little pain, it can do no harm, and is sometimes followed by permanent agglutination of the abscess walls. When the abscess is large and the skin attenuated, the only hope for a speedy recovery lies in the prompt and complete evacuation of the pus. The use of the Vienna paste, blisters, and multiple incisions to effect this have been properly abandoned. The last-named method, particularly recommended by Vidal, Zeissl, and Langston Parker, and still practised by many older practitioners, is prone to result in the formation of a number of ulcers in the groin. In the great majority of cases, a single incision, with a narrow blade, is all the operative interference called for. Until two decades ago the incision usually made was parallel to the inguinal fold and extended the entire length of the swelling. The result of such an incision is almost invariably a wound the edges of which are in apposition except when the patient is lying down. Again, when ulceration of the margins of the wound ensues, the skin is very apt to become undermined or inverted. Hence very ungainly cicatrices result that might ordinarily be avoided by making the incision in a different manner. A good procedure is the following: To prevent excessive pain, a small quantity of carbolic acid is brushed over the point where the opening is to be made. The long and narrow knife, while held perpendicularly to the surface of the body, is then gently forced into the centre of the fluctuating area. The skin and capsule of the gland resist slightly the intrusion of the blade. When this resistance has been overcome, the cutting edge of the knife is turned about ninety degrees, and then withdrawn. With a little pressure, or by inserting a grooved director into the cut, the accumulated pus rapidly escapes. To prevent a too speedy closure of the opening, it is advisable to insert a strip of iodoform gauze or carbolized gauze, which also insures the ready drainage of the abscess cavity. When this is removed, after remaining twenty-four hours, it will invariably be seen that the aperture, measuring from the one-eighth to the one-fourth of an inch in diameter, is circular in outline, and sufficiently large to permit the escape of the pus as rapidly as it is formed. Many surgeons, after opening a bubo, practice injections of tincture of iodine or other antiseptic solutions. While this practice cannot be harmful, it seems superfluous save in those very rare cases in which septic changes supervene in the interior of the abscess cavity. As already remarked, the bubo often has a tendency to point at a number of places, when it of course becomes imperative to use the knife repeatedly. The practise of Milton, who uses a very large needle for this purpose, might profitably be imitated in timid patients and by practitioners unaccustomed to the use of the knife. By the use of poultices, or of spongio-piline frequently dipped into hot water, suppuration and granulations are stimulated so that usually the simple bubo is entirely closed in a few weeks. Not so, however, in case of extensive periadenitis and of virulent bubo. When the abscess is very large, a somewhat freer incision is necessary. Even here it seems to me better to make it parallel to the axis of the limb, irrespective of the direction of the bubo. The wound thus made is more easily maintained patent, and in making it there is manifestly less danger of wounding the deep-seated vessels than from the incision as generally made. Almost immediately after opening a large bubo there will be a sinking in of the integument. In the course of a week, or even less, this skin becomes discolored, curled upon itself, or undermined. Under these circumstances it is always best to remove the cutaneous flaps with a few strokes of the curved scissors, thus converting the abscess into an open ulcer. In other cases fistulæ in the groin continue to discharge indefinitely. They should be freely laid open with the knife or elastic ligature, and the exuberant granulations removed with the sharp spoon. When once the bubo has been converted into an open ulcer its treatment is ordinarily successful, no matter what applications be made, although, at times, stimulating medicaments are called for to overcome the sluggishness of the granulations. Among the large number of agents specially recommended for this purpose there should be mentioned iodoform, tincture of iodine, tannin, permanganate and chlorate of potash, preparations of iron, and boric acid. Iodoform usually acts so satisfactorily as almost to merit being called a specific in the treatment of the open bubo. Applied in the form of ointment alone, or with tannic acid, or in ethereal solution (iodoform ʒ iv., ether. fort. 30.), it soon causes the floor of the ulcer to be covered with small and healthy granulations which rapidly lead to its permanent closure. When the odor of iodoform is an insurmountable objection to its use, the permanganate of potash (.5 to 30.), in aqueous solution, is an excellent substitute. Where the reparative process is exceptionally protracted from the size of surface involved, skin-grafting has been used with as much success as in other portions of the body.

Attention has already been directed to the fact, that the lymphatic gland covered by granulations often presents itself in the floor of the bubonic ulcer, or is hidden in the depths of a sinus. The gland then acts as a foreign body. It should therefore be removed as soon as it is discovered. Whether this is to be accomplished with scissors, ligature, or Volkman's spoon must be determined by the circumstances of the case and the predilections of the surgeon in charge.

It is self-evident that the systemic treatment of patients afflicted with buboes must not be neglected. Nutritious diet and tonics are always indicated after the process of suppuration has become somewhat protracted. This is particularly true if the ulcer shows any tendency to phagedæna. It is then that cod-liver oil, quinia, and alcoholic stimulants are indicated, and that the most effective local measures must be resorted to. Blisters, fuming nitric acid, the carbo-sulphuric paste, bromine, and even the actual cautery must, at times, be employed before the tendency of the ulcer to spread is permanently overcome and the process of cicatrization is well established.

It would be improper to close the subject of treatment without the mention of the sulphide of calcium as an agent which produces the marked effect of preventing suppuration in simple buboes. Given in doses of one-half to one grain every four hours for a number of days, it often prevents the formation of pus. In my dispensary and private practice it has been given a fair trial, and is considered a valuable adjunct in the treatment of simple buboes. Syphilitic buboes, as a rule, require no local treatment. As the secondary manifestations of the disease disappear under treatment, the enlargement of the inguinal glands also subsides. When the induration in them persists after other symptoms have yielded to treatment, inunctions with the mercurial ointment or the oleate of mercury over the ganglia will often cause their reduction in size. Compression might also be resorted to in these cases with marked benefit. *Joseph Ransohoff.*

[1] Rindfleisch: Pathol. Gewebelehre, p. 169.
[2] Jullien: Traité Pratique de Mal. Vener., 1879, p. 429.
[3] Dict. Nouveau de Sc. Médicales, vol. v., p. 764.
[4] Grünfeld: Real Encyclop., Bd. ii., p. 613. [5] Art. Bubo, Quain's Dict.
[6] Ven. Dis., p. 479 (4th ed.). [7] Rindfleisch: Loc. cit., p. 172.

BUCHU (U. S. Ph.; *Buchu Folia*, Br. Ph.; *Buchu* or *Bocco*, Codex Med.). The leaves of the three species of the genus *Barosma* (*Diosma* of the older authors), mentioned below. The genus includes fifteen species of fragrant shrubs of the order *Rutaceæ*, growing in South Africa. They have smooth and slender upright branches, opposite leaves, and axillary white or pink flowers. These latter are often to be found in the bales of leaves as imported. They are spreading, regular, and perfect. The calyx is small, with five sepals; the corolla larger, with five petals; stamens, ten; pistils, five, each two-ovuled; fruit dry. There is a very strong family resemblance among the species, which are distinguished from each other mostly by the leaves.

1. *Barosma crenulata* Hook., has oblong, oval, or obovate, obtuse leaves, with crenulate margins; length from two to four centimetres (three-fourths to one and one-half inch); breadth, about one centimetre (two-fifths inch). The leaves of this variety have not been very common in the market of late years.

2. *Barosma serratifolia* Willd., is the source of the variety called "Long Buchu." It has linear-lanceolate, three-nerved leaves, tapering at both extremities, and terminating a little suddenly at the apex, in a large blunt gland. These leaves are the longest and narrowest of the officinal buchus; they are from two and a half to upward of four centimetres long, by about half a centimetre wide (one to one and a half by two-tenths inch).

3. *Barosma betulina* Barthing, has short, broad, cuneate-obovate leaves, with sharply denticulated borders, and recurved apices. Dimensions one and a half or two centimetres long, by about one centimetre broad (one-half to three-fourths by two-fifths inch). This species supplies the "Short Buchu, the commonest and least expensive variety; its leaves are thicker and more resistant than the others.

Besides these, one or two other *Barosmas* occasionally reach us, as well as the leaves of another plant in the same order, called *Empleurum serrulatum* Ait., but they are not common.

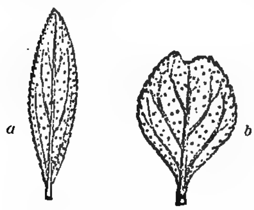

FIG. 528.—Buchu Leaves. *a*, *B. crenulata*; *b*, *B. betulina*. (Baillon.)

The varieties of buchu are usually imported separately, associated with flowers or fruit, and small twigs; they have an agreeable, camphoraceous, and mint-like odor, and a warm, aromatic, faintly bitter taste. They become yellowish-green by drying; those of *B. betulina* are often nearly straw-colored. They are smooth and glabrous, and contain numerous large oil-cells, scattered beneath the under surface, and at each serration of the border. The upper surface of the leaves contains a layer of mucilage yielding cells. There is a great difference in the price of the different varieties, the long bringing often several times as much as the short. No difference in medicinal value has been proved.

The use of buchu was taught to the settlers of Cape Colony by the Hottentots about the beginning of the present century. It has been exported from Cape Town for upward of fifty years, and appears to be more used in England and America than on the continent of Europe.

COMPOSITION.—The most prominent constituent is the *volatile oil*, of which Flückiger obtained 1.56 per cent. from the leaves of the short variety. It is a brownish liquid, with a peppermint-like odor and aromatic taste. Upon standing, it deposits a few crystals of a stearoptene, *Barosma camphor* (diosphenol), with the same odor. The leaves also contain considerable mucilage.

USE.—Buchu is usually classed with diuretics, but it does not appear to increase the secretion of urine much, and is not generally given for that purpose. For uræmia, dropsy, or conditions in the course of chronic degeneration of the kidneys, where efficient stimulation of their action is really needed, no one would think of giving buchu. On the other hand, it does modify the urine, often very perceptibly, during its elimination, by the presence in that excretion either of its oil or of some perhaps antiseptic decomposition product derived from it. Its generally accepted usefulness in chronic inflammatory and suppurative processes in the kidneys or bladder is in harmony with this suggestion, and associates buchu logically with some other remedies often given for the same conditions; those, for instance, containing arbutin, benzoic, or salicylic acid, etc. The relief from pain and irritability in these distressing cases is often very marked and grateful. In simpler cases of irritability of the bladder, with frequent painful and straining micturition from transient causes—cold, disordered digestion, etc.—it is often very useful. There is no better form in which to administer buchu than an infusion or "tea," made extemporaneously at the home of the patient. The dose is indefinite, but from ten to twenty grammes may be used in the course of the day. There is also a fluid extract (*Extractum Buchu Fluidum*, U. S. Ph.), strength, $\frac{1}{1}$.

ALLIED PLANTS.—See RUE for the order Rutaceæ. They are nearly all aromatic plants.

ALLIED DRUGS.—Bearberry (*Uva Ursi*), pipsissewa (*Chimaphila*), etc. Numerous so-called "diuretic" oils and resins. Sandal, fleabane, copaiba, as well as benzoic acid, salicylic acid, and other antiseptics. The coniferous oils, *e.g.*, turpentine, are somewhat similar, but much more irritating. For a list of unclassified vegetable "diuretics," see, further, COUCH-GRASS. *W. P. Bolles.*

BUCKBEAN (*Folia Trifolii fibrini*, Ph. G.; *Menyanthe* ou *Trèfle d'eau*, Codex Med.), *Menyanthes trifoliata* Linn.; Order, *Gentianaceæ*, *Menyantheæ*. A widely distributed bog-herb, with a creeping perennial rhizome, and rather thick and leathery bright-green leaves. The flowers are borne on an upright spike-like raceme, arising from the end of the rhizome, and are a little more than a centimetre across (one-half inch). The calyx is small, five-parted; the corolla regular, five-lobed; the divisions white or pink, recurved and covered on the upper surface with numerous erect papillæ. Stamens, five; ovary, one-celled, with two placentas; ovules rather numerous. Fruit, a capsule. The stem (rhizome) is about a centimetre in diameter, long and branched, leafy only at the extremities, with distinctly marked nodes, and numerous adventitious roots. It is occasionally gathered and used for the same purposes as the leaves, which alone are the official part. They arise from long, sheathing petioles. The leaflets are nearly entire, oblong or ovate, blunt, about eight centimetres long and half as wide (one and one-half by three inches). They have a disagreeable odor when fresh, which disappears upon drying; the taste is bitter and nauseous.

Buckbean grows in cold swamps and moist places in Europe, Asia, and America, and has naturally been long known and used in medicine, but is now very little called for—in the United States not at all. Its bitter principle, *menyanthin*, was separated in 1860 by Kromayer, as a white, amorphous, bitter powder, and shown to be a glucoside—sugar and a liquid oil, "menyanthol," being the result of its decomposition.

ACTION.—In moderate doses it is a simple bitter tonic, similar to, but less agreeable than, the other Gentianaceæ. In large doses it is cathartic, and sometimes emetic. Dose, as a tonic, one or two grammes. An extract or tincture may be made from it, but they are not officinal in the United States.

ALLIED PLANTS.—*Menyanthes* differs very much in habit from the other *Gentianaceæ* (see GENTIAN).

ALLIED DRUGS.—Also see GENTIAN. *W. P. Bolles.*

BUCKTHORN (*Frangula*, U. S. Ph.; *Cortex Frangulæ*, Ph. G.); *Rhamus Frangula* Linn.; Order, *Rhamnaceæ*, is a large shrub, from three to six metres (10 to 20 feet) in height, with alternate leaves, and small axillary clusters of pentamerous, regular, perfect, white flowers. The receptacle (or calyx-tube) is bell-shaped, and bears the floral envelopes and (opposite) stamens upon its border. The ovary is free, three- or four-celled (and ovuled). Fruit, a small, purple-black drupe, with from one to four seeds. Leaves elliptical, entire, with from nine to seventeen

diverging nerves; these veins, and the young twigs, pubescent—the rest of the plant smooth.

Frangula is a native of almost every part of Europe, even to the extreme north, also of Northern Africa and of portions of Asia. It has been known as a medicine for several centuries, but its employment in the United States is comparatively modern. It is also used for dyeing. The bark is the officinal portion, and it should be "collected at least one year before being used." The description in the Pharmacopœia is as follows: "Quilled, about one twenty-fifth of an inch (1 millimeter) thick; outer surface gray-brown, or blackish-brown, with numerous small, whitish, transversely-elongated, suberous warts; inner surface smooth, pale brownish-yellow; fracture in the outer layer short, of a purplish tint; in the inner layer fibrous and pale yellow, nearly inodorous; taste sweetish and bitter."

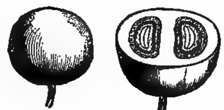

Fig. 529.—Berry of Rhamnus Frangula. (Baillon.)

The composition of *Frangula* is more interesting from a chemical than from a medical point of view, as it does not appear to have any single active principle which may be said to represent it. One of its most notable constituents is *frangulin* (Rhamnoxanthin), a lemon-yellow, crystalline, odorless, and tasteless glucoside, yielding, by decomposition, *frangulic* and *difrangulic acids*, the former in yellow, the latter in red crystals. *Emodin*, one of the ingredients of Rhubarb, has also been found in Frangula, as well as a little *tannic acid.* Frangulic acid is said to be cathartic, but needs further trial.

Action and Use.—Fresh Frangula bark is an irritating and griping purgative, often an emetic as well. By drying it loses a portion of its virulence, and is even said to continue to grow milder for one or two years. Hence the requirement of the Pharmacopœia, quoted above. It is then, in small doses, a gentle laxative, especially adapted to the treatment of habitual constipation, as it retains its power in continuous administration better than most articles of its class, and also combines well with bitter tonics and stomachics. Dose, one or two grammes (gr. xv. ad xxx.) once or twice daily. The Fluid Extract (*Extractum Frangulæ Fluidum*, U. S. Ph.) is the only officinal preparation, strength 1/1. The addition of Elixir of Orange, Syrup of Ginger, or some other aromatic vehicle, is desirable. In full cathartic doses (four grammes) it is apt to occasion nausea and griping, and is not so good as other cathartics.

Allied Plants.—The genus *Rhamnus* is a large one, numbering about eighty shrubs or small trees, distributed over the whole north temperate zone. Similar cathartic and emetic properties appear to be present in many of them. They also furnish a number of yellow and green dyes and paints.

Fig. 530.—Rhamnus Cathartica. (Baillon.)

The species most like *Frangula* in appearance and medical value is *Rhamnus Purshiana* De Cand., of the Western United States; a small tree, about six metres (20 ft.) in height, the bark of which, under the name of "*Cascara Sagrada,*" has been recently quite extensively given for exactly the same purposes as Frangula itself. It is, perhaps, a little milder, but not otherwise distinguishable. *Rhamnus Cathartica* Linn. (*Rhamni Succus*, Br. Ph.; *Fructus Rhamni Catharticæ*, Ph. G.; *Neprun purgatif*, Codex Med.), is the species to which the name "Buckthorn," placed for convenience at the head of this article, really belongs. It is a smaller shrub than *Frangula*, with fewer-nerved, often opposite leaves, and polygamo-diœcious flowers. The sterile branches are thorny. The fruit is round, about a centimetre in diameter (⅜ inch), black and shining when fresh, much shrivelled when dry. Its taste is bitter and disagreeable. It is also cathartic and emetic, but its active principle, like that of Frangula, has not been isolated. It contains a yellow, neutral, crystalline substance, *rhamnin*, which may be made to yield "*rhamnus sugar*," and a valuable yellow coloring matter, *rhamnetin*, common to this and a number of other species of *rhamnus*, whose fruits or bark have been used in the arts. Rhamnin resembles quercitrin, the coloring matter of oaks and some other plants, in many respects.

Buckthorn Juice, from which a syrup is generally made for administration, is an old cathartic now very properly going out of use. It is harsh and disagreeable. Evaporated and rendered alkaline, the juice makes the paint called Sap Green.

Chinese Green is prepared from the barks of *Rhamnus chlorophora* and *R. utilis* Decne. Several European and Eastern species, such as *R. infectoria* Linn., and *R. saxatilis* Linn., furnish the "French Yellow Berries," and *Rhamnus amygdalina* Desf., the "Persian Yellow Berries," now or formerly used in dyeing. They owe their color to *rhamnetin*, mentioned above.

The Order, although a good-sized one, contains but few other plants of economic interest. *Zizyphus vulgaris* Lamk., cultivated in Southern Europe, furnishes "Jujube Berries," from which an edible jelly is made. *Gouania Dominigensis*, "Chew-stick," also belongs to it.

Allied Drugs.—See Rhubarb. *W. P. Bolles.*

BUDDING. One of the methods of asexual reproduction in the animal kingdom as well as in the vegetable world.

It differs from fission (*q. v.*) in that the offspring produced from the bud has never formed an integral part of the parent organism, but arises as an outgrowth of some part of the parent.

In its simplest form, as in the case of the fresh-water Hydra (Fig. 531), the process is as follows: Certain cells of the wall of the hydra grow and multiply, forming a hollow outgrowth on the side of the parent (*a*). As this enlarges and develops, tentacles appear at the outer end, and a mouth is formed (*a′*). Later, communication with the digestive cavity of the parent is cut off, and the young hydra feeds itself, and at a still later stage becomes separate from the parent.

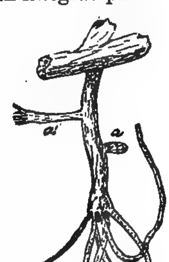

Fig. 531.—Hydra (enlarged). Showing buds, *a*, *a′*.

In other cases the buds remain permanently attached, and thus are formed colonies (see Colonies, Animal), or stocks of greater or smaller size and complexity, often supported by a skeleton. Such are the coral stocks and many others. One example from the protozoa is shown in Fig. 532, and one from the polyzoa in Fig. 533.

Fig. 532.—Dinobryon, an Infusorian (greatly enlarged). Showing apical budding.

Buds may be formed at various places on the parent or colony. Very frequently they grow from the side of the parent—lateral budding, as in hydra and most corals; or on the top—apical budding (Fig. 532). Sometimes buds are formed from stolons developed from the cœnosarc of the colony (Fig. 533, *b*), or from the cœnosarc directly.

A variety of apical budding, called axial, consists in the production of new segments, which may remain permanently united, as in most worms, or become detached, as in the tape-worm.

In some cases internal buds are produced, as in Echinococcus (*q. v.*), and in the redia of the fluke-worms.

Closely united with this last method is the formation of germs, or unfertilized eggs, from organs corresponding to the ovary (parthenogenesis, *q. v.*), which develop into animals like the parent, as in the production of drone-bees, plant-lice, etc.

A variety of this method, pædo-

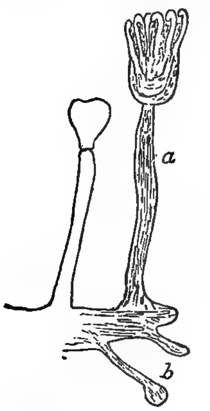

FIG. 533.—Fredericella, a Polyzoan (much enlarged). Showing adult bud, *a*, and stolon, *b*.

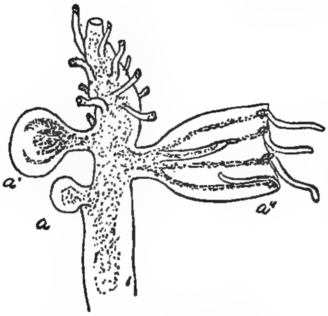

FIG. 534.—Syncoryne, a hydroid. A nutritive zoöid with medusa (reproductive) buds (*a*, *a'*, *a''*) in various stages of development.

genesis, consisting of the production of germs from animals still in the larval form, is exemplified in certain flies, as Cecidomyia, Miastor.

In some cases the buds of a colony are of different forms and functions. This is best seen in the hydroids, in which the feeding zoöids are of a different form from the reproductive zoöids (Fig. 534, *a*, *a'*, *a''*). This method of budding leads to colonial division of labor. *E. A. Birge.*

BUFFALO LITHIA SPRINGS, VA. *Location and Post-office*, Buffalo Lithia Springs, Mecklenburg County, Va., twelve miles from the Scottsburg station on the Richmond & Danville Railroad, and seven miles from the Clarksville station on the Richmond & Mecklenberg Railroad. The surrounding country is rolling, and generally known as the "Buffalo Hills." Immense ledges of sandstone crop out here and there. There are three springs, the respective analyses of which, by Professor Wm. P. Tonry, of Maryland, are as follows:

ANALYSES.—Results expressed in grains per imperial gallon.

SPRING No. 1.	Grains.
Sulphate of magnesia	1.530
Sulphate of alumina	8.180
Sulphate of potash	0.463
Sulphate of lime	19.251
Bicarbonate of lime	39.277
Bicarbonate of lithia	1.484
Bicarbonate of iron	0.500
Chloride of sodium	1.256
Chloride of silica	1.725
Phosphoric acid	traces
Iodine	traces
Organic matter	small amount
Total number of grains per gallon	73.693
Sulphuretted hydrogen	5.9 cub. in.
Carbonic acid gas	69.1 "

SPRING No. 2.	Grains.
Sulphate of magnesia	0.885
Sulphate of alumina	9.067
Sulphate of lime	33.067
Carbonate of potash	29.300
Bicarbonate of lime	14.963
Bicarbonate of lithia	2.250
Bicarbonate of baryta	1.750
Bicarbonate of iron	0.300
Chloride of sodium	4.921
Chloride of silica	1.873
Phosphoric acid	traces
Iodine	traces
Organic matter	small amount
Total number of grains per gallon	98.376
Sulphuretted hydrogen	8.3 cub. in.
Carbonic acid gas	59.2 "

SPRING No. 3.	Grains.
Sulphate of magnesia	0.150
Sulphate of alumina	3.035
Sulphate of lime	2.353
Carbonate of potash	1.852
Bicarbonate of lime	2.524
Bicarbonate of lithia	traces
Bicarbonate of iron	3.774
Chloride of sodium	0.217
Chloride of silica	0.570
Phosphoric acid	traces
Organic matter	small amount
Total number of grains per gallon	14.475
Sulphuretted hydrogen	3.4 cub. in.
Carbonic acid gas	11.6 "

The flow of Spring No. 1 is at the rate of about 40 gallons; No. 2, 50 gallons, and No. 3, 45 gallons per hour.

THERAPEUTIC PROPERTIES.—These waters are alkaline and sulphuretted. They are not cathartic, as a rule, but are decidedly diuretic. As they contain lithia salts, their use is suggested in the condition known as "lithæmia," and their efficacy in this and allied disorders, is confidently testified to by many eminent physicians. Spring No. 2 seems to be the most potent in its effects upon the digestive and excretory organs. These waters are, therefore, especially indicated in dyspepsia resulting in or consequent upon the accumulation and deposition of uric acid or its salts in the system. The urine speedily becomes alkaline and abundant under their use, thus affording conditions for the solution and removal of deposits of uric acid and lime oxalate. They are widely used in gout, rheumatism, Bright's disease, dyspepsia, etc.

The climate is very agreeable. It is warm during the day in summer, but the nights are generally cool enough to make a blanket desirable. Though no systematic observations have ever been made as to rainfall and average humidity, the air of the locality has the reputation of being remarkably dry. There are several flourishing schools and academies in the immediate neighborhood, and churches of various denominations are near by. Visitors are provided for in cottages, there being accommodations for about three hundred. The ordinary drinking-water is limestone. *Geo. B. Fowler.*

BUGLE, Codex Med.; *Ajuga reptans* Linn.; Order, *Labiatæ*. A hairy European annual, with a rosette of spatulate, finely serrate leaves near the ground, and an upright, slightly leafy stem. The flowers are small and blue, labiate, but with very small upper and larger lower lips. Stamens four, didynamous, with divergent anthers. The leaves are officinal (in France); they have a slightly bitter and astringent taste, but little odor, and no valuable medical properties. Dose indefinite.

ALLIED PLANTS AND DRUGS.—The genus contains about thirty species, a number of which have had their day as medicines. *Ajuga Chamæpitys* Linn. (Ground pine) grows also in this country. It is more aromatic than Bugle, and reputed to be "stimulant, diuretic, etc."

Bugle may also be compared with a number of bitter and not very aromatic Labiates, nearly all of which have become obsolete, excepting as home remedies. Bugle-weed (*Lycopus*), Skullcap (*Scutellaria*), Horehound (*Marrubium*), Motherwort (*Leonurus*), etc., are examples. *W. P. Bolles.*

BUGLOSS (*Buglosse*, Codex Med.), *Anchusa officinalis* Linn., and *A. italica* Retz; Order, *Borragineæ*. These two European herbs have the general characteristics of Borage, from which they differ in having no appendages to the anthers, and in their less spreading flowers. The first-named is a hairy biennial, with branched stem, and violet blue flowers; the second has shining leaves and sky-blue flowers. Both are bland plants, with odorless and tasteless leaves, slightly bitter flowers, and mucilaginous roots. They have no medical value whatever.

ALLIED PLANTS, etc., see BORAGE. *W. P. Bolles.*

BURDOCK (*Lappa*, U. S. Ph.; *Bardane*, Codex Med.); *Arctium Lappa* Linn. (*Lappa officinalis* All.; *L. major* Gaertn.); Order, *Compositæ, Cynaroideæ*. Burdock is a

native of Europe, but is common everywhere as a garden weed. It is a rank-growing, bitter, disagreeable plant, from one to two metres (three to six feet) in height, with a stout, succulent, branching stem, and great, coarse, heart-shaped leaves. The flower-heads are clustered along the stem and branches; they are rather small, and look like miniature thistles. The involucre is ovoid and green; its scales numerous, imbricated in several rows, with spreading, sharp, stiff, inwardly hooked tips. Flowers tubular and perfect, rose-purple.

The root is the officinal portion, and should be gathered at the end of the first season, or the beginning of the second; it is biennial, fleshy, and usually simple. When dried, it is in gray-brown, shrivelled pieces, as large as the thumb, and twenty or thirty centimetres long (eight to twelve inches), often split, to facilitate drying. The hairy bases of leaf-stalks remain attached to its upper end. Internally it is light-brown, with a rather thick bark, a distinctly radiated woody zone, and a white, often broken and missing pith. Odor slight, taste mucilaginous and slowly bitter.

Burdock contains *inulin*, *mucilage*, some *tannic substance*, and a *bitter extractive*. It is an old medicine, whose reputation depends upon pure empiricism. As an alterative and an antisyphilitic it is still occasionally used, but is more called for as an ingredient in proprietary "Hair Restorers" and "Blood Purifiers" than in serious medication. Dose from two to four grammes. There is no officinal preparation here. An extract and an infusion (*Tisane*) are included in the Codex.

ALLIED PLANTS.—In Europe, the roots of the two following are collected indiscriminately with those of the preceding species: *Arctium minus* Schk. (*Lappa glabra* Lam.; *L. minor* D. C.), a smaller plant with more closely clustered, slightly woolly heads and purple-tipped scales; *A. Bardana* Willd. (*L. tomentos* Lam.), with the heads woolly and the scales of the involucre not hooked; also smaller than *A. Lappa*. The roots are all similar. Other nearly related plants are thistles (*Carduus*, *Cnicus*, etc.). For *Compositæ*, see CHAMOMILE.

ALLIED DRUGS.—The class of vegetable alteratives and antisyphilitics, and the number of substances which have been given for psoriasis, lepra, chronic rheumatism, and "scrofula," are too large and indefinite for critical comparison (see SARSAPARILLA). *W. P. Bolles.*

BURIAL. The natural regard felt by men for the bodies of those who were dear to them during life, as well as the necessity of removing from sight or contact objects which rapidly become offensive, has in all ages led to the adoption of some mode of disposing of the dead by which it was thought that these ends could best be attained. Three methods have chiefly been employed, at different times and in different countries, for the disposition of the dead: mummification, incineration, and interment.

Mummification was practised by the Egyptians, from the most ancient times to the sixth century of the Christian era. The continued preservation of the body is now attained by the somewhat analogous process of embalming. The ancient Egyptian method, long lost, has at last been brought to light through the finding of a description of the art in a mummy case. The modern method of embalming, by injection of various preserving fluids through the arterial system, is, however, expensive and little used (see Embalming).

The second method, that of incineration, obtained generally among the Romans down to the close of the empire, and among the Hindoos the practice was never abandoned. Within the last decade a strong movement has been on foot to re-establish this custom, which is by far the most convenient and sanitary of all the methods; all germs of disease being destroyed by the burning of the body, and the unsanitary influence of the gases generated by putrefaction being entirely avoided. For the present methods of incineration see Cremation.

The practice of disposing of the dead by interment is quite equally old with either of the foregoing methods. The Hebrews usually disposed of their dead in this manner, though they seem also to have practised cremation. Among the Greeks, in historical times, the bodies of the dead were indifferently interred or burned, and a common word [θάπτειν] is used for either method of burial. As the Christian religion gradually obtained the ascendency, the practice of burning bodies was discontinued, and it became customary to bury the dead in the immediate neighborhood of the churches, in grounds consecrated for the purpose. Thus in towns, as the population increased and interments became more numerous, the burial-grounds became entirely too small for the necessities of the public. Under such circumstances, the accumulation of bodies within a limited space led, at each new burial, to scenes which shocked the minds of the community. Furthermore, the disengagement of gases resulting from the decomposition of these bodies proved exceedingly injurious to the general health. In London, in some of the poorer districts, the soil of the church-yards was raised two, three, or even four feet in height in a few years, and in the immediate neighborhood of such burial-grounds, epidemic diseases were both more common and more fatal. Within a period of thirty years there had been interred, in a space not exceeding 318 acres, 1,500,000 bodies.[1] Now, as it takes ten years, on an average, for the human body to entirely decay, some idea may be formed of the condition of things existing in those days. At the same time it must be remembered that the duration of this process of decay varies very greatly according to the climate, the nature of the soil, and the character of the coverings in which the body is enveloped. A colder climate retards decomposition, while in warmer or tropical countries it takes place more rapidly. Low damp grounds, especially when percolated by water, hasten decomposition; dry, high, well-ventilated ones, on the contrary, retard it. Envelopment in leaden or metallic coffins retards decomposition, provided they be perfectly air-tight and of sufficient strength to resist the pressure of the gases generated within, which is often exceedingly powerful, sufficiently so, at times, to bulge the sides of, or even to rupture, a leaden casket too lightly constructed. Orfila and Leseur, in their experiments, found nothing but the skeletons left of bodies that had been buried fourteen, fifteen, and sixteen months. This period was, however, unusually short. Where numerous bodies have been buried in a space of limited size, and within a comparatively short period of time, the earth becomes saturated with the products of decomposition to such a degree as to become incapable of further absorbing them. Decomposition, in such cases, is retarded, and its products escape directly into the atmosphere. Besides the contamination of the atmosphere in the immediate neighborhood of burial-grounds, evil effects have resulted from the escape of carbonic acid gas into the cellars of buildings in the neighborhood. As a notable instance of this may be mentioned the penetration of the gas into the cellars of houses in the immediate vicinity of the Cemetery of the Innocents at Paris, some years ago.

Knowing, as we do to-day, the great importance of stringent sanitary regulations in regard to our cemeteries, most of the intramural church-yards, in large towns and cities, have been discontinued as places of burial by the various boards of health, and a system of extramural interment has been substituted. In this way a vast necropolis has gradually grown up in the neighborhood of many of the larger cities; as, for example, Père La Chaise, near Paris; Woking, near London; Greenwood, near New York; and Mount Auburn, near Boston. These cemeteries occupy high, dry, and well-ventilated locations. They have no drainage leading to the neighboring cities, and are much to be preferred to the formerly common intramural cemeteries. At the same time the putrefaction of such an immense number of corpses, even though it take place at some little distance from the city, must contaminate in no small degree the atmosphere. In country villages, where the church-yard was situated upon an eminence and in the centre of the hamlet, most destructive epidemics of various diseases have been known to occur. At the time the causes of these epidemics were

very imperfectly ascertained; but, with our present knowledge, it would be safe to assume that in many instances fluids containing the germs of the disease had percolated from the cemetery into wells or cisterns in the village.

An acre of ground will accommodate from one hundred to one hundred and thirty bodies per year, not more. And each body should have at least thirty square surface feet, and should be placed at a depth of six feet from the surface. Direct interment is preferable to either the use of bricked vaults or entombing, as it favors the more rapid decomposition of the tissues of the body and the neutralization, by the surrounding mass of earth, of the noxious effluvia and gases resulting therefrom.

Burying Alive.—The facts that persons have occasionally presented all the ordinary signs of death yet have afterward revived, and that others have undoubtedly been buried as dead who were still living, have repeatedly drawn attention of both individuals and governments to the necessity of guarding against so terrible an occurrence. Winslow, the celebrated anatomist, is said to have been twice nearly buried alive, and it was in consequence of this that he published his treatise on the signs of death, in which he comes to the conclusion that incipient putrefaction is the only sign that can be relied on. Putrefaction comes on at variable periods, and it is not always convenient to wait for its occurrence. Bouchart proposes to substitute the careful exploration of the cardiac region by auscultation. During a fainting fit the heart is still heard to beat, and in the dying, after the last expiration has proclaimed that all is over, after the pulse at the wrist has ceased to beat, and after the hand applied over the heart finds everything still, the ear placed upon the same region still. hears for a time the beating of that organ; but when, after having listened for a sufficient time, the practised auscultator ceases to distinguish the beat of the heart, life is over ("Traité des Signes de la Mort," etc., by E. Bouchart). In examining the hearts of a number of the dying Bouchart found that the longest interval between the pulsations was six seconds; from a similar investigation Rayer found it to be seven seconds. "If," concludes the latter, "the absence of the pulsation of the heart is verified by the auscultator for a period equal to fifty times that of the longest observed interval, or for an interval of five minutes, the patient may be pronounced with certainty to be dead." Even this, however, admits of some exceptions. In new-born infants, for example, the action of the heart may cease for a longer period and yet the child revive, and the same thing is said to have occurred in older individuals in the cold stage of Asiatic cholera.

J. McG. Woodbury.

[1] Report on a General Scheme of Extramural Sepulture, by General Board of Health, London, 1850.

BURIAL, LAW OF. In England, in 1879, the Home Secretary informed a delegation from the Cremation Society, which was organized the preceding year, that the regulations regarding burial-permits did not recognize cremation, and an appeal would have to be made to Parliament to legalize the practice; but no bill was passed, as the sentiment against cremation was quite strong. In 1882 occurred the first judicial decision on the question, but it was not conclusive. In that case a Miss Williams was directed by the will of Henry Crookenden to burn his dead body, and to call upon the estate for the expenses. Miss Williams' brother was executor of the will, and as he had the body buried instead of burned, she applied after a time for a permit to remove and *reinter* the body. When possession of the body was obtained, it was removed to Italy, and there cremated.

Suit was then begun for the expenses, amounting to £321, but the court decided against the claim, on the ground that possession of the body had been obtained under the false pretence of reinterring it. The court refrained from deciding what was the legal status of cremation. In 1884, however, the question came squarely before Justice Stephen, in a case in which a father was attempting, on his own land, to burn the body of his child, and the neighbors combined to prevent his doing so. The father was indicted for committing a misdemeanor; but, after a very careful and learned examination into the subject, Justice Stephen decided that cremation was not illegal. This practically settled the question; but for many reasons it has been thought desirable to get the approval of Parliament, and bills have been introduced for that purpose.

The English law has secured for many centuries, even as far back as A.D. 750, according to Lord Stowell, the right of burial to every Englishman. He says: "In England, about the year 750, spaces of ground adjoining the churches were carefully enclosed and solemnly consecrated and appropriated to the burial of those who had been entitled to attend divine service in those churches, and who now became entitled to render back into those places their remnants to earth, the common mother of mankind, without payment for the ground which they were to occupy, or for the pious offices which solemnized the act of interment."

This common-law right of interment was subject, in many ways, to the control of the incumbent of the church, who was held to have a fee in the church-yard. The rector could not absolutely prevent the burial of any person living in the parish, but he could require fees, and might refuse to read the burial-service, or to allow a headstone to be erected. Some offensive attempts, on the part of clergymen of the established church, to prevent the burial or adornment of the graves of dissenters has led to a good deal of agitation and some legislation. By recent acts of Parliament there may be consecrated and unconsecrated parts in the cemetery, and in the latter the rights of dissenters are considerably enlarged.

The right of burial does not include, according to Lord Stowell, the right to be buried in a coffin; and where in one case the relatives wished to bury the deceased in an iron coffin, a mandamus directing the authorities to permit the interment was refused. It was, however, decided that such an interment might be made upon payment of larger fees than usual.

It was considered that the use of iron coffins, more or less indestructible, would rapidly fill up the cemeteries, and as these were held for future generations as well as the present one, no general mode of interment should be allowed which had a tendency to fill the ground unduly.

Bodies cannot be removed from one burial-ground to another without the consent of a Secretary of State, except in the case of unconsecrated grounds, when the permission of the ordinary is sufficient. The right of burial implies the duty of burial on the part of surviving friends or relatives. In one case it was held that the owner of the house in which a person died must see to it that he was decently interred. In practice, however, where there are no friends or relatives to assume the duty, it is borne by the public, and the expense made a charge upon the community. This is also the custom and the law in this country as well as in England.

The regulations of the various States of the Union on the subject of burial differ somewhat, and in general the subject is delegated to the smaller communities, such as town and city corporations, which have the power to make ordinances covering the mode of burial.

In most cities burial is not allowed without a license, and the right to disinter a body to search for evidences of crime or disease is reserved by the public.

The private rights of the deceased, if they may be so termed, and those of surviving relatives form a very interesting subject, and the legal decisions bearing on one point or another constitute quite an extended branch of the law. It will bring the principles involved more clearly into view, if the subject is considered under these three heads: 1, The body after death and before burial; 2, the body at burial; 3, the body after burial.

1. In the case of death, the custody of the body is usually in the hands of the near relatives, though the law regards the executors as having the lawful custody. The deceased may give directions regarding the place and manner of his burial, which will be binding in case they are known before the time of burial. If they are not discovered until afterward, the courts have in some instances

declined to order a removal. The deceased cannot sell his body, for purposes of dissection, for instance, so that the contract could be enforced in a court of justice. A person having lawful possession of the body, by virtue of such an agreement, could probably hold it as against the relatives, though the courts will give him no help in trying to secure possession.

There is no such thing as ownership of a dead body inhering in the deceased himself, the relatives, or the executors, in the ordinary sense of barter and sale. The courts have in many instances declared that there is no such thing as ownership, and yet at other times a sort of *quasi-ownership* has been recognized in the executors, to enable them to acquire possession of the body in order to bury it according to the wishes of deceased. The ordinary rule is thus expressed in a Massachusetts case: "A dead body is not the subject of property, and after burial it becomes a part of the ground to which it has been committed—'Earth to earth, ashes to ashes, dust to dust.'"

In the case of dead bodies cast upon the seashore, there is no ownership permitted to the finder, either in the bodies themselves or in any articles of value found upon them.

The quasi-ownership which the courts at times recognize is practically only the right of custody, and involves the duty of burial. This, as has been said, belongs to the executor in case of a will, and, where there is no testamentary disposition, then to the widow, husband, or next of kin.

2. The body at burial. The custody of the body being lawfully in the hands of the executors or next of kin, they have the right to select the place of burial, but they have not the right to override the known wishes of the deceased, and courts of equity have often after interment directed a change to be made. The right to select a burial-place is not an absolute one, and in a recent case in New York, in which long after the interment a will was discovered, which gave detailed directions as to the place of burial, the court declined to order a removal. The brief time elapsing between death and burial usually prevents any legal questions arising. These generally are caused by the attempt to remove the body after interment. The right of custody of the body will give the right to exclude objectionable persons from the funeral, if it is held in a private house, as was recently decided in a Rhode Island case. When the services are held in a church or public place, there is no decision on the subject, but it is not considered that there would, in that case, be any right of exclusion belonging to the executors or next of kin.

3. The body after burial. The law bearing on this division of the subject is mainly concerned with the question of removal. Cemetery authorities, health officials, executors, or relatives may all have the right to remove a dead body, but the statutes of all the States prescribe the conditions of such removal, or else require an application to be made to a court, which judges upon the propriety of the application, and bases its decision not entirely upon the desires of the applicants, but largely upon the supposed interest which the public has in the permanence of interments. The law is said, with great truthfulness, to favor the "repose of the dead," and an order for disinterment will not be lightly made.

It cannot be said that an order of a court is necessary in every case of disinterment. The rules of cemetery organizations, or the health laws of the community, provide for cases in which all persons interested are united in desiring a removal. In all cases, however, in which there is a dispute as to the right, courts of equity will intervene, and issue such orders as are deemed proper upon the circumstances of each case. The cases touching on removal, when broadly generalized, develop these principles:

(1.) The husband or wife has not an absolute right to remove the body against the will of the next of kin.

(2.) The next of kin cannot remove the body against the will of the husband or wife.

(3.) The next of kin cannot remove the body against the will of other next of kin of equal relationship, and public institutions or corporations have no rights as against the next of kin.

(4.) The owner of the burial-lot has no such absolute right to the realty as to carry with it the ownership of the bodies buried in the lot. These are held in trust.

The recent cases seem to develop the trust idea somewhat, and, as the claim of ownership is repudiated, it is natural that this principle of guardianship, or trusteeship, should become generally received, whether it is held to inhere in the cemetery organizations, in the owner of the burial-lot, in the relatives, or in the public. It is probable that the interest of the public, as the guardian of the general health, would be held by the courts to be paramount to all other considerations, in all cases in which it seems to conflict with private desires. *Henry A. Riley.*

BURLINGTON. The accompanying chart, representing the climate of the city of Burlington, Vt., and, obtained from the Chief Signal Office in Washington is

Climate of Burlington, Vt.—Latitude 44° 29′, *Longitude* 73° 15′.—*Period of Observations, January* 1, 1872, *to June* 15, 1883.—*Elevation of Place of Observation above the Sea-level,* 214 *feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below the mean monthly minimum temperature.	Greatest number of days in any single month on which the temperature was above the mean monthly maximum temperature.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January....	16.8	21.4	18.7	18.9	30.0	12.1	27.4	8.9	59.0	32.0	Zero	− 24.8	23	28
February...	17.8	24.7	20.7	21.0	29.7	13.5	30.1	12.3	53.0	38.0	6.0	− 20.5	23	18
March......	24.8	31.6	27.4	27.9	36.0	19.7	36.7	20.3	60.0	46.3	10.0	− 20.5	28	27
April.......	38.0	45.9	39.8	41.2	50.3	34.6	49.6	34.3	75.0	56.0	33.0	10.0	21	24
May.........	52.3	61.5	53.4	55.7	61.5	51.3	65.8	47.0	91.0	75.7	38.0	27.0	24	22
June........	63.0	72.0	62.4	65.8	70.6	61.6	73.4	54.2	94.0	83.8	51.0	37.0	21	19
July........	68.2	76.8	67.9	70.9	73.1	69.0	80.1	61.1	96.0	84.0	61.0	47.0	22	18
August.....	65.6	74.9	65.9	68.8	71.3	65.8	77.9	59.5	97.0	84.0	52.0	40.0	25	21
September..	57.9	66.0	58.8	60.9	66.2	57.1	70.1	53.6	90.0	78.0	46.0	32.0	20	20
October.....	46.2	53.2	48.0	49.1	54.3	45.1	58.6	42.6	78.0	64.0	36.0	22.0	22	21
November..	33.3	37.1	34.0	34.8	41.0	26.7	42.8	29.3	65.8	47.0	23.0	− 10.0	19	21
December..	22.1	25.4	23.2	23.5	33.2	15.0	32.5	18.2	56.3	41.0	6.0	− 19.0	25	27
Spring......	......	......	......	41.6	47.6	38.5	......	......	......	......	......	......	......	......
Summer....	......	......	......	68.5	71.5	66.6	......	......	......	......	......	......	......	......
Autumn....	......	......	......	48.2	51.0	43.9	......	......	......	......	......	......	......	......
Winter......	......	......	......	21.1	23.0	16.0	......	......	......	......	......	......	......	......
Year........	......	......	......	44.8	47.9	42.0	......	......	......	......	......	......	......	......

	J	K	L	M	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall.	Prevailing direction of wind.	Average velocity of wind.*
						Inches.	From	Miles.*
January...	83.8	72.3	12.7	3.2	15.9	1.90	S.	8.3
February..	73.5	70.6	10.9	5.3	16.2	0.86	S.	7.6
March.....	80.5	69.6	11.2	5.1	16.3	1.57	S.	8.1
April	65.0	63.6	11.6	5.5	17.1	1.72	N.	7.7
May	64.0	62.5	13.3	6.9	20.2	2.41	S.	6.8
June.......	57.0	64.8	15.1	6.4	21.5	2.84	S.	6.1
July	49.0	66.1	16.2	7.1	23.3	3.76	S.	5.7
August....	57.0	68.5	15.4	8.7	24.1	3.56	S.	5.3
September.	58.0	70.5	14.1	6.0	20.1	3.26	S.	6.7
October....	56.0	69.0	12.2	5.2	17.4	3.23	S.	7.2
November.	75.8	69.8	10.5	2.2	12.7	1.94	S.	8.6
December..	75.3	73.1	10.2	1.7	11.9	1.43	S.	8.4
Spring.....	111.5	65.2	36.1	17.5	53.6	5.70	S.	7.5
Summer...	60.0	66.6	46.7	22.2	68.9	10.16	S.	5.7
Autumn...	100.0	69.8	36.8	13.4	50.2	8.43	S.	7.5
Winter	83.8	72.0	33.8	10.2	44.0	4.19	S.	8.1
Year	121.8	68.2	153.4	63.3	216.7	28.48	S.	7.2

* Miles per hour.

here inserted for convenience of reference. A detailed explanation of this and of other similar charts will be found under the heading CLIMATE; where also the reader may find suggestions as to the method of using these charts. *H. R.*

BURNET ROOT (*Radix Pimpinellæ*, Ph. G.).

1. *Pimpinella Saxifraga* Linn. (*Carum Saxifraga* Baillon); Order, *Umbelliferæ*, has a smooth, round, branched, nearly naked stem, from thirty to fifty centimetres high.

2. *P. magna* Linn. (*Carum magnum* H. Bn.) is twice as tall, has an angular stem, more divided leaves, and longer styles, otherwise the plants are very similar, and both furnish the *Radix Pimpinellæ* of the German Pharmacopœia. They have tapering, perennial roots, divided above into several or many crowns, usually simple or sparingly branched below. Their leaves are once or twice pinnate; their inflorescence and flowers are nearly like those of anise.

The roots of the two species are very similar, but that of *P. Saxifraga* is smaller and simpler than that of the other. They are about as large as the little finger, from eight to twenty-five centimetres long (3 to 9 inches), longitudinally wrinkled and yellowish or pale brown externally. A transverse section shows a thick whitish bark, with numerous resin-canals, and brown, radiating medullary lines in it; a dark, narrow cambium ring and yellow wood. Pith generally absent. The odor of Burnet Root is strong and aromatic, but disagreeable, the taste at first insipid and mucilaginous, afterward bitter and pungent.

CONSTITUENTS.—A yellow *Essential Oil*, smelling like that of parsley, a crystalline substance called *pimpinellin* (?), *resin*, *sugar*, *gum*, etc.

USES.—The properties of Burnet are those of a great many umbelliferous roots wh'ch depend upon peculiar oils and resins for their use. It has been considered to be "stomachic, expectorant, diuretic, and diaphoretic." On account of its pungency it has been chewed as a stimulant in paralysis of the tongue, as well as for toothache. As it serves none of these purposes very well, and is disagreeable in odor and taste, it may as well be dropped from use. Dose, from half a gramme to two grammes (0.5 to 2 Gm. = gr. viij. ad xxx.).

ALLIED PLANTS.—See ANISE for the Order *Umbelliferæ*.

ALLIED DRUGS.—The root of *Pimpinella nigra* Willd. is occasionally gathered for Burnet. It is darker colored, and yields, upon distillation, a blue oil. Lovage and Parsley in the same order, and Pellitory, in some respects resemble Burnet. *W. P. Bolles.*

BURNS AND SCALDS. Burns are produced by fire or dry heat, and scalds are the results of the application of hot fluids or moist heat. Clinically these forms of injury are very much the same. The degree or severity of the burn varies according to the density and duration of the heat and the capability of the solid or liquid for retaining caloric. Burns or scalds may be caused by the rays of the sun, by contact with fire, boiling water, oils, heated or molten solids, caustic alkalies, or concentrated acids; the amount of injury caused varying from a simple erythematous blush to the charring of a limb or part.

The effect also varies according to the mode of application of the heat. To quote Wilson: "In degree, heat may be feeble but prolonged, or it may be strong and instantaneous, strong and continued for a brief period, or strong and continued for a long period."

The flame of burning ether or alcohol, if momentary, causes a superficial burn, while the contact of burning sealing-wax or boiling oil, the ability of which to retain caloric is greater than water, because of its greater density, gives rise to much more serious injury. Molten metal when it simply strikes the skin causes vesication; but if it gains access to and surrounds a limb, complete charring and destruction of tissue occur.

A scald, even if severe, may leave the hairs uninjured, and from this circumstance it may often be diagnosticated from a burn, but when the liquid is hot and dense the hairs are often destroyed as in burns.

Concentrated acids and caustic alkalies, either in solid or liquid form, act with great power on the soft tissues, and so cause injuries of the most serious character. Burns from this cause may be distinguished by the absence of vesication and other symptoms found when fire has been the cause.

Phosphorus acts energetically, causing deep and rapid burns and inflammation of surrounding tissues, and fatal results have attended its improper handling. Surface burns from lightning stroke present about the same appearances as burns from other sources. The skin is reddened and blistered, and the hair is singed or entirely destroyed.

Burns from nitric acid produce yellowish stains or patches, while sulphuric acid and caustics generally cause reddish or red-brown discoloration.

Sunburns are generally so slight as to require only a brief notice, yet occasionally a person having a tender skin may suffer severely from only a brief exposure to the sun. This burn is characterized by diffuse redness of the exposed part, with more or less smarting pain. The face, neck, forearms, and hands are usually affected. Grave symptoms sometimes arise when a large surface (two-thirds) is implicated, and a case has been reported in which death occurred from violent dermatitis, with gangrene, following sunburn.

Burns are usually classified as of the first, second, or third grade. Dupuytren's division into six degrees is too complicated, and though long in vogue, has been generally discarded by modern writers. The following classification is that of Thomas George Morton, and is, I think, the best:

BURNS OF THE FIRST DEGREE.—Characterized by erythema, irritation, and inflammation of the skin without vesicles.

BURNS OF THE SECOND DEGREE.—Vesication, inflammation of the skin, and formation of vesicles and bullæ.

BURNS OF THE THIRD DEGREE.—Eschars; gangrene, superficial or deep, involving the skin or the subcutaneous tissues; carbonization of a part or of the entire body.

The prognosis depends upon the depth of the injury and its extent, upon the susceptibility of the skin to the action of heat, and upon the general characteristics and physical condition of the patient. Burns of the first and second degrees generally result favorably, the patient recovering rapidly; in those of the highest degree, however, when the surface involved is very extensive, the prognosis is more grave, and even burns of the first degree may prove fatal when a great extent of surface is involved. It is generally accepted that, if one-half or even one-third of the surface has been burned or scalded, death, from some physiological cause as yet not clearly explained, will be inevitable; and this usually happens during the first twenty-four or forty-eight hours. I think, however, that

much depends upon the patient's previous physical condition and turn of mind. In my service at the Bellevue Hospital, in this city, where I had considerable experience with burns, I remember having seen two cases in which over half of the body had been burned to varying, first and second, degrees, but the patients, one being a strong and healthy engineer, and the other a robust Italian laborer, both recovered; while, on the other hand, even slight burns in aged and enfeebled subjects were sometimes a cause of death through shock. However, even with a smaller extent of surface involved, the prognosis should be guarded. In burns of the third degree, which result from the application of intense heat, the prognosis will depend not merely upon the depth of the burn, but also upon the part of the body involved, and upon the age, sex, and temperament of the patient.

SYMPTOMS.—*In burns of the first degree* there is more or less redness of the skin, which disappears on pressure, accompanied by swelling and pain. This continues for a greater or less period, and then the epidermis is exfoliated and the natural conditions are restored. Recovery generally ensues in a few days and no permanent injury results. The constitutional symptoms are usually slight. Sometimes there is, however, an irritative fever, and if a great extent of surface be injured, and if the patient be very susceptible, shock may be quite marked and even death may result.

In burns of the second degree the pain, redness, and swelling are more marked than in the first degree, and the hyperæmia being greater, there is a tendency to exudation, and vesicles are formed. These, when large in size, are called bullæ. They either come on at once or form in a few hours. The serum is usually transparent, though sometimes it may be discolored by blood. Usually in the formation of the vesicles there occurs no damage to the skin, but sometimes suppuration and ulceration may take place. The constitutional symptoms vary according to the extent and severity of the injury. Shock is almost always present, and death results in some cases simply from this cause. Sometimes there is found a congestion of all the viscera, and death may result from cerebral effusion with delirium. With the rise in temperature, albumen is commonly found in the urine, and during the period of reaction ulceration of some portion of the mucous membrane of the bowel frequently occurs.

Burns of the Third Degree.—In this group are classed all cases of gangrene resulting from burns affecting the skin or subcutaneous tissue. Now, according to the intensity and duration of the heat, the skin alone, or the muscles, nerves, blood-vessels, and bones may be destroyed even to carbonization. This latter is, fortunately, rare, but it sometimes happens that portions of limbs are entirely burned off while the individual is in a drunken stupor or suffering from epileptic coma. The constitutional symptoms are, as may be supposed, severe. If reaction occur at all, the symptoms become at once quite grave, according to the extent of the injury. In some cases death soon takes place from coma, due to cerebral congestion. The lungs, kidneys, and other organs are intensely congested, and this period of inflammation, so called, extends from the reaction to the beginning of exhaustion, during which time the dead tissues are being thrown off by suppuration. This exhaustion is sometimes increased by hæmorrhages from the necrotic tissues. In all cases of burns of the third degree renal congestion is constant and gives rise to albuminuria.

THE COMPLICATIONS OF BURNS may be considered under the heads of Cerebral, Respiratory, and Intestinal. Cerebral irritation often appears quite early, and inflammation may follow and be accompanied by violent delirium. Convulsions and coma may occur in a fatal case.

Laryngitis, bronchitis, or pneumonia may occur from burns or scalds, the first frequently following the inhalations of hot steam. Œdema may be excessive, requiring tracheotomy in order to avert impending death from dyspnœa. Bronchitis and pneumonia are frequently observed to follow burns of the chest and neck.

Intestinal ulceration is one of the peculiar results of severe burns, and follows the intense congestion of the digestive tract that sometimes takes place. The intestinal lesions are present in varying degrees, from the simplest gastric irritation and diarrhœa to severe inflammation of the stomach and intestines, going on to duodenal ulcer, perforation, and death.

TREATMENT. — This varies in accordance with the severity of the injury. The indications are: First, to relieve the pain and overcome the shock; secondly, to guard against congestion and inflammation of the internal organs; and thirdly, to counteract the exhaustion incident to sloughing.

Local Treatment.—In burns of the first degree there are usually no marked constitutional symptoms, but the local ones may be quite severe. These may be relieved by local applications of olive-oil, vaseline, oxide of zinc, or other ointments of a soothing nature. Powdered bicarbonate of soda is a most excellent application, and often affords great relief in simple burns when freely dusted over the affected surface. Other alkaline applications may be used, among which a mixture of linseed-oil and lime-water, called "Carron oil," may be mentioned as having long been popular. Flour, starch, white-lead, paint, or any substance that excludes the air and makes a coating for the nerve filaments that have been irritated or uncovered will relieve the pain. Molasses has been used when nothing better could be found at hand in a case of emergency. The addition of carbolic acid to any of the ointments, or vaseline or oil, is of much advantage, as it relieves pain and thoroughly disinfects any discharge that may occur. It produces a certain amount of surface anæsthesia, and as carbolic acid is absorbed but feebly from any mixture with an oil, the danger of poisoning is not great. The urine should, however, be watched for any trace of the acid, as cases of such poisoning have occurred. An ointment made of boric acid and vaseline is of great service, as it allays pain and is perfectly safe. These remedies may be spread upon lint or old muslin and laid upon the burned surface, the parts being then enveloped in layers of cotton-batting and all held in place by a roller-bandage.

It is well to bear in mind that only one part of a burned patient should be exposed at a time, in order to avoid surface chilling, and that the greatest care should be used not to tear away any burned portion of clothing which adheres to the injured surface, lest the cuticle should also be torn off. Vesicles and bullæ should not be broken, but should be punctured at their lowest point and their contents allowed to drain off, and care should be taken that the cuticle be not rubbed off, as it affords the best covering for the excoriated surface.

Dressings need not be changed oftener than every second or third day, unless the amount of discharge be very great, or the odor quite marked.

When the sloughs have separated, the ulcerated surfaces beneath are soon covered by florid granulations, which may require astringent applications or strapping with adhesive plaster. The treatment now becomes that of a simple ulcer, and may be guided by the same rules. Much good may be accomplished and deformity be avoided by keeping the various parts carefully separated, and by maintaining them in an appropriate position either by fixation on splints or by some proper mechanical appliance.

In the ulcerative stage skin-grafting is of great service, and large and indolent ulcers may be made to heal quite readily by this means (see article on Skin-grafting). Even transplantation of skin, as recommended by Wolf, may be employed with advantage in certain cases.

Treatment of Burns from Corrosive Acids, Caustic Alkalies, etc.—The corrosive or mineral acids which most often cause burns are sulphuric, nitric, and muriatic. In burns from these acids the application of water is to be avoided, as it causes, when mixed with the acid, a great and sudden rise of temperature. The proper treatment is to apply whiting or levigated chalk, which causes brisk effervescence, and at once neutralizes the acid; after this the part may be washed off with water. If this be done promptly, no more serious injury will result than a faint erythematous redness, accompanied by a slight sensation of smarting. Should by chance any of

these substances be splashed into the eye, the organ should be well bathed in lime-water, and subsequent inflammation treated in the usual manner. Occasionally these substances are taken into the mouth, or swallowed, and, if prompt measures be not adopted, they may cause rapid destruction of the tissues and speedy death. The carbonates of sodium, potassium, calcium, or magnesium are the antidotes, and should be given freely.

Do not flood the stomach with water under these circumstances, for when the substance is an acid, especially sulphuric, the addition of water causes a sudden and great rise of temperature. Large draughts of milk may be given after the exhibition of any of the antidotes above named. (See article on Antidotes.)

The caustic alkalies are soda, potassa, ammonia, and quick-lime. These act by suddenly abstracting moisture from the tissues. A fresh burn of this nature should be treated with vinegar, or with any other mild acid, which neutralizes the alkali and forms with it an unirritating salt. A burn of the eye should be treated in the same way, care being taken to dilute the acid to a proper degree.

When nitrate of silver has been swallowed or applied in excessive quantity to any of the mucous membranes, chloride of sodium, or common salt, is the proper antidote, the insoluble chloride of silver being formed. Carbolic acid acts by coagulation of albumen, and therefore in poisoning from this substance the proper antidote is the white of egg, a remedy which is always at hand in every house.

The treatment of shock from burns or scalds should be the same as when this condition arises under other circumstances. (See article on Shock.)

When reaction has commenced, a generally supporting plan of treatment is in order. Thirst, which is usually intense, should be allayed by small lumps of ice placed in the mouth, or by occasional sips of carbonated water. Constipation is quite common during the first two or three days following a burn, and a laxative enema is the best means of relief. The gastric and intestinal disturbance often calls for treatment. The diarrhœa during exhaustion due to the profuse suppuration is best treated by opium combined with astringents, and by pepsin and bismuth. The diet should be simple but nourishing, and absolute rest is to be enforced.

John McG. Woodbury.

BURSÆ. (The term is Neo-Latin, derived from the Greek *βυρσα*, a leathern sac or bottle; equivalents in German, Schleimbeutel, Sehnenscheiden; in French, bourses séreuses.) These are spaces formed in the general connective-tissue of the body by the pulling or sliding stress arising from the independent action of contiguous parts. They probably originate, like the cavities of joints (see Arthrology), by an enlargement of the connective-tissue lymph-spaces, usually occurring between the harder parts of the skeleton and their muscular, tendinous, and cutaneous coverings. Bursæ are common near joints, because there the projecting processes and angular motion of the bones produce the conditions necessary for their formation. Having a common origin they frequently communicate with the cavities of joints, and formerly such bursæ were termed bursæ synoviales, those of an independent character being termed bursæ mucosæ. This distinction is now abandoned, as the contained fluid is the same in both cases, and bursæ in the same situation may in different individuals, and in the same individual at different ages, sometimes communicate with the joint, sometimes not. When tendons rub over resisting surfaces, bursal spaces are formed about them, called synovial sheaths (vaginæ tendinum). As these are of precisely the same nature as other bursæ, differing only in shape, it will be proper to consider them under the same head.

The structure of all these varieties is the same, and is similar to the cavities of joints, there being always a membraniform wall of connective-tissue, more or less condensed, which secretes a small quantity of synovial fluid, just sufficient for lubrication. Synovial fringes, or villous processes may exist as in joints, and a rich network of vessels supplies the wall. The removal of the original connective-tissue may not be complete, portions being left which divide into chambers or spaces the bursa, which is then termed multilocular. In synovial sheaths the membrane envelops the tendon as the peritoneum does the intestine, a connection existing on one side, formed of two layers of membrane through which the blood-vessels pass to reach the tendon. From its analogy to the mesentery this is called, when complete, a mesotenon; when partly obliterated, as in the fingers, the remaining bands are termed vincula tendinum. As in joints, every grade of completeness is seen in the synovial membrane, there sometimes being only a very imperfect sac in which the lining tissue is but little condensed, the whole resembling a connective-tissue space.

The number and extent of the bursæ vary according to the habits and age of the individual. A certain number of those which are largest and most constant are found in the fœtus, but subcutaneous bursæ are never found at that age, and seldom in youth, because then the elasticity of the skin is such that it stretches when pressed or pulled, and therefore has but a slight sliding motion over the harder parts. Certain occupations involving friction, or pressure of tools or other appliances may cause bursæ in unusual situations, and they may occur also because of distortion or deformity occasioning pressure. With age there is an increase in their size, their number, and the frequency of their communication with joints. This is a fact of considerable surgical importance, as the opening of a bursa may involve a joint cavity in inflammation which may result in ankylosis, or the loss of a limb.

Bursæ are subject to the same pathological disturbances as affect synovial sacs elsewhere. Those which are subcutaneous are more exposed to injury from direct violence, while luxations, fractures, and general constitutional disturbances (pyæmia) are more likely to affect the deeper ones. Any kind of inflammation may ensue, from the acute variety occasioned by violence, and characterized by pain and the rapid production of pus, to a slow, chronic form without pain, and only evident from the distention of the sac by an abnormal amount of fluid. As bursæ are modified connective-tissue spaces, and thus in immediate connection with the lymphatics, the opening of them is likely to be followed by diffuse inflammation of considerable extent, and it should therefore be done with precaution, except in case of acute suppurative inflammation, when the incisions should be early and free.

A severe bruise or sprain may rupture the capillaries of the synovial wall and cause an effusion into the cavity of a bursa forming a hæmatoma. Injuries of this kind are also common in fractures, being frequently masked by the principal lesion until convalescence, when the tendons are found to be disabled. It is for this reason that passive motion should be early practised in Colles' fracture of the lower end of the radius. Cases are recorded of tendons being displaced by direct violence, as the biceps tendon from the groove of the humerus,[1] and the peroneal tendons are occasionally pulled from their grooves on the outer side of the foot by muscular force alone. There must necessarily be some injury to the bursal sheath in such cases.

Acute suppurative bursitis is usually caused by a blow, bruise, or wound, but it may also originate from cold or some obscure cause. It often extends in a remarkable manner, and if not checked may occasion wide destruction of contiguous parts, involving tendons, periosteum, and bones. A milder form is characterized by a sero-purulent exudation and a slower course. Undue pressure and friction may produce this, as in the affection of the præpatellar bursæ known as "housemaid's knee," or of the olecranon bursæ known as "miner's elbow." In some cases no pus is formed, the inflammatory process merely occasioning an increase of serous fluid in the bursal sac. As in pleuritis or peritonitis, this fluid may be flocculent with coagulated fibrin, and either yellowish or coffee-colored from admixture with blood. A true fibrinous exudation may be deposited, as in inflammation of serous membranes. When this occurs in bursal sheaths the motion of the enclosed tendon occasions a crackling

sound. The disorder is called tenosynovitis, and is common in pianists.

The treatment of these cases depends upon the intensity of the inflammation; in sthenic cases lead-water and evaporating lotions, afterward free incisions to liberate pus; in others, evacuating the contents of the sac by the aspirator or by valvular incision, securing drainage and applying pressure.

Repeated and slight irritation of a bursal sac is the usual cause of chronic bursitis, which may be characterized by a thickening of the wall from the gradual deposit of organized lymph. The entire cavity may be thus filled up, presenting a tumor of almost cartilaginous hardness which may be excised. Instead of this the bursa may become filled with discrete, structureless bodies of about uniform size, white or yellowish in color, and about the size of rice-grains or melon-seeds. These are believed to be detached coagula, shaped by the motion of contiguous parts. Occasionally remains of excrescences (synovial fringes), fatty matter, cholesterine crystals or deposits of phosphate or carbonate of lime are found. All such contents should be evacuated by means of an incision sufficiently large. Special occupations favor such inflammatory products; they are rare in children, and are occasionally connected with disorders of menstruation or with pregnancy.

A chronic bursitis may be manifested merely by a simple distention of a bursa by serous fluid. Normally the secretion of the cavity is readily reabsorbed by the vessels, but when inflammation sets in reabsorption ceases, and besides, an abundant effusion occurs. When the bursa itself is enlarged, the affection is known as hygroma. In connection with bursal sheaths of tendons, it not infrequently happens that the fluid collects in a cavity which is contiguous to the sheath but separated from it by a wall. This affection is termed ganglion, and is popularly known as "weeping sinew." Some believe this to be an infiltration into the outlying connective-tissue through a small slit in the sheath wall, while Paget suggests that it is a cystic enlargement of a villus of the synovial fringe. Gosselin[2] appears, however, to have clearly shown that ganglion is occasioned by the enlargement of small loculi in the connective-tissue that have become detached from the sheath by the usual processes of growth. As in other synovial sacs, rice-grain bodies and other phenomena of inflammation are found in the ganglion, and it may become multilocular and take on the general structure of a bursa.

Hygroma is usually treated by setting up an acute inflammatory process, either by inserting a seton of horsehair or by injection of tincture of iodine. A blister will sometimes reduce it. A popular and usually effective remedy for a small ganglion is to break the sac into the surrounding connective-tissue, by striking it smartly with a flat object like a book.

In scrofulous subjects, bursal sheaths are occasionally affected by fungous synovitis, a disorder essentially the same as that which produces chronic strumous arthritis or white swelling. Usually arising from a sprain or a bruise, it is commonest in the sheaths behind the malleoli. It is characterized by an extraordinary increase in the villosities of the synovial membrane, these becoming a true granulation-tissue, and yielding a sero-purulent product. The whole of the sheath in a given locality may be involved, and the mischief usually spreads to the neighboring joint. The only chance of arrest is by excising the fungous growth.

A knowledge of the exact location of bursæ is of great importance with reference to diagnosis. Unfortunately the subject has been somewhat neglected by descriptive anatomists. While some bursæ have received names and are accurately described, others are but seldom mentioned, and authors differ as to their nomenclature. In the following list, which has been carefully compiled from various sources, an endeavor has been made to describe and name all the bursæ which have been found in the human body, omitting only those which are merely accidental. The figures show the situation of the principal bursæ in the most important surgical regions.

List of Bursæ.

HEAD.—*Bursa galeæ capitis.* Between the aponeurosis of the occipito-frontalis and the pericranium, directly over the occipital protuberance.[3] Only in aged subjects.

B. sacculi lachrymalis. Between the lachrymal sac and the internal palpebral ligament.[4] Rare.

B. trochlearis oculi. In the pulley of the superior oblique. Constant.

B. capsulæ oculi. Between the capsule of Tenon and the globe of the eye. Usually imperfect. Hyrtl[5] cites cases of effusion into the sac.

B. circumflexi palati (Rosenmüller). Where the tendon of the tensor palati turns around the hamular process.

Bursæ massetericæ. There appear to be several bursæ between the masseter and the subjacent structures. Rosenmüller mentions one between the two portions of the masseter, and one between the masseter and the external pterygoid. Hyrtl[6] mentions one between the muscle and the temporo-maxillary articulation. Nancrede supposes that these may become continuous, and when inflamed form a cystic tumor reaching to the base of the skull.

B. spinæ sphenoideæ. Hyrtl[7] states that when the temporo-maxillary joint is unusually large a bursa occurs between the spine of the sphenoid and the joint capsule.

B. anguli mandibuli. Subcutaneous over angle of the jaw. Rather rare.

B. sublingualis. Between the tongue and the mucous membrane, outside the genio-glossus. Frequently called

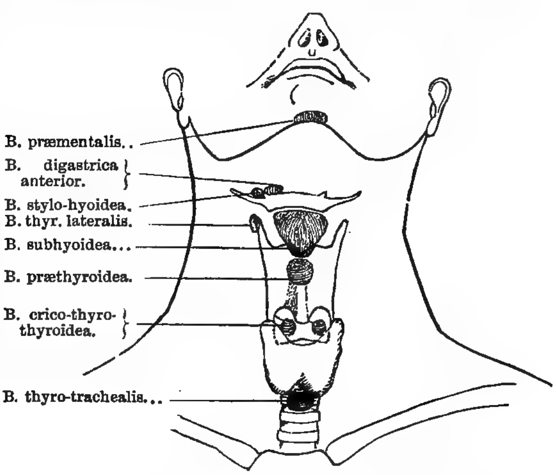

FIG. 535.—The Principal Bursæ of the Neck, in Front.

Fleischmann's bursa, from its discoverer.[8] Some deny its existence.[9] Tillaux has frequently found it, and believes that acute ranula is caused by a rupture of Wharton's duct into it.[10]

B. præmentalis (Fig. 535). Subcutaneous at lower border of the symphysis of the chin. Quite constant.[11]

NECK.—*B. digastrici posterior* (Rosenmüller). Between the posterior belly of the digastric and the sterno-mastoid.

B. digastrici anterior (Rosenmüller) (Fig. 535). Where the tendon of the digastric passes through the fascia binding it to the hyoid bone, or through the stylo-hyoid muscle.

B. stylo-hyoidea (Fig. 535). Under the insertion of the stylo-hyoid and the hyoid bone.

B. supra-hyoidea (Verneuil). Between the upper surface of the hyoid bone and the genio-hyo-glossi. Rare.

B. subhyoidea (Fig. 535). Between the hyoid bone + combined insertion of sterno-hyoid, omo-hyoid, and stylo-hyoid muscles, and the thyro-hyoid membrane. Larger in men than in women. Often called Boyer's bursa.

B. sterno-hyoidei (Rosenmüller). Between the insertion of the sterno-hyoid and the hyoid bone.[12]

B. præthyroidea (Fig. 535). Between the skin and the upper part of the thyroid cartilage in old subjects. Often wanting.

B. thyroidea lateralis (Gruber[13]) (Fig. 535). Between the inferior constrictor and the greater cornu of the thyroid cartilage. Found in 5 cases out of 50.

B. crico-thyro-thyroidea (Calori[14]) (Fig. 535). Between the lateral lobes of the thyroid body and the crico-thyroid.

B. thyro-trachealis (Calori) (Fig. 535). Between the isthmus of the thyroid body and the trachea. Usually single and median; there may be one on either side. Most common when the pyramid of the thyroid body is well developed, especially when it is attached to the hyoid bone.

B. musculi thyroïdei. Between the levator thyroidei, when that muscle is present, and the thyroid body. Calori figures one in a case of goître.

B. omo-hyoidei. Between the sterno-mastoid and the middle tendon of the omo-hyoid. Mentioned by Nancrede, but not generally noticed by authors.

B. aortico-tracheales (Calori). Between the aorta and the trachea. A large one extends from the origin of the innominate to the left carotid, and from the upper border of the arch to the bifurcation of the trachea. A second one is described as posterior to this, also a small one which extends between the left carotid and the trachea. Some one of these was found in 13 out of 40 examinations. If the pericardium extends upward, the large aortico-tracheal bursa is small.

B. vertebræ prominentis. Between the skin and the spinous process of the seventh cervical vertebra. Nancrede states that this is quite large, and may inflame from pressure of a heavy overcoat.

TRUNK.—*B. subclavia* (Rosenmüller). Within the fibres of the rhomboid ligament.[15] Not constant. May simulate a costo-clavicular articulation, of which, indeed, it seems to be the beginning.

B. submammaria. Between the mammary gland and the pectoralis major. Rare, but interesting, as it may be involved in a case of mammary abscess.

B. anguli-sterni. Subcutaneous over the angle between the first and second pieces of the sternum. In carpenters and cabinetmakers.

B. hyper-xiphoidea. Subcutaneous over xiphoid cartilage. Usual in shoemakers and rachitic children.

B. suprapubica. Beneath the pubic attachment of the rectus abdominis. Duval[16] reports that inflammation of this has been known to occur as a sequel to croupous pneumonia. Not mentioned by authorities generally. Schreger mentions a subcutaneous bursa at the side of the suspensory ligament of the penis.

B. costæ-primæ. Between the muscles of the back and the tuberosity of the first rib. Mentioned by Nancrede. It is probably rare, as the principal authorities omit it.

B. sacralis (Luschka). Over spinous process of fourth or fifth sacral vertebra, or over the articulation of the sacrum and coccyx. Usual in old subjects.

B. coccygea (Luschka). Between tip of coccyx and sphincter ani. Common.[17]

B. phrenico-hepatica anterior (Von Brunn[18]). Between the left lateral ligament of the liver and the under surface of the diaphragm in front. Found in 31 cases out of 64. Its enlargement might simulate a diaphragmatic hernia.

B. phrenico-hepatica posterior (Von Brunn). Between the same structures behind. Found in 2 cases out of 64.

SHOULDER.—*B. trapezii.* Between the aponeurotic part of the trapezius and the base of scapular spine (3 times in 12, Synnestvedt).

B. latissimi dorsi. Between the latissimus dorsi and the inferior angle of the scapula. Recent observers (Henle, Heineke, Synnestvedt) do not find this.

B. spinæ scapulæ;

B. supracromialis. These are subcutaneous, found in those who carry burdens.

B. infra-scapularis. Between the inferior angle of the scapula and the chest-wall. Usually between subscapularis and serratus magnus. May be of considerable size, and by crepitation, when inflamed, simulate crepitant râles or pleuritic fremitus.[19]

B. subdeltoidea (Fig. 536). Between the under surface of the acromion + structures arising therefrom (lateral portion of coraco-acromial ligament, deltoid muscle) and the capsular ligament of the shoulder-joint.[20] Constant. Many authors describe the upper part of this bursa separately as *B. subacromialis.* This portion may be separate, but it usually communicates, and the whole should be considered as a single large multilocular bursa. Rarely communicates with the joint. Its inflammation may simulate dislocation of the biceps tendon (Nancrede).

B. coraco-brachialis (Monro). Between the lateral part of the subscapularis and the short head of the biceps + coraco-brachialis. Sometimes communicates freely with B. subdeltoidea. Also known as B. subcoracoidea.

B. coraco-brachialis minor (Gruber). Under a rare muscle, which arises from the anterior and internal part of the coracoid process.

B. fossæ infraclavicularis (Gruber) (Fig. 536). Between two layers of the coraco-clavicular fascia (costo-coracoid membrane), in front of the coracoid process. Frequent (1 in 3), more common in women.

B. coraco-clavicularis media (Gruber) (Fig. 536). Between the conoid and the trapezoid ligaments. Frequent (1 in 2). May simulate a coraco-clavicular articulation.

B. coraco-clavicularis lateralis (Gruber) (Fig. 536). Between the coracoid process and the trapezoid ligament. Occasional (1 in 5).

B. subtendinea pectoralis minoris. Under insertion of pectoralis minor. Rare (1 in 30 or 40, Gruber).

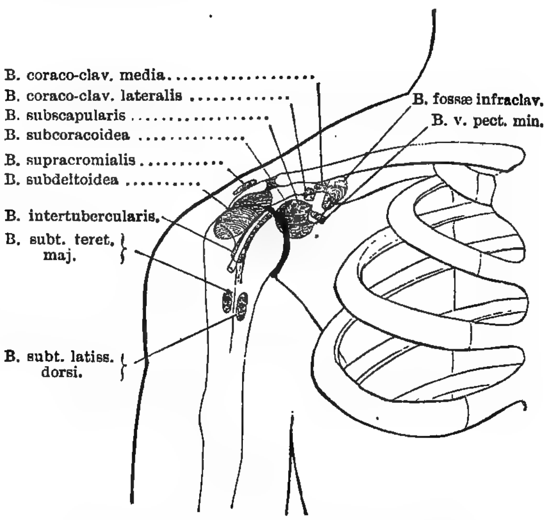

FIG. 536.—The Principal Bursæ about the Shoulder.

B. vaginalis pectoralis minoris (Gruber) (Fig. 536). Around tendon of pectoralis minor. Rare (1 in 10).

B. subscapularis (Fig. 536). Between the subscapularis and the neck of the scapula. Constant. It always communicates with the joint, and may properly be considered as a diverticulum of the capsule.

B. subcoracoidea (Gruber) (Fig. 536). Between the upper edge of the subscapularis and the B. subscapularis.[21] Found 10 out of 12 times (Synnestvedt); in two of these cases it communicated with B. subscapularis.

B. subtendinea subscapularis (Synnestvedt). Between the tendon of the subscapularis and the capsule (2 times in 18).

B. intertubercularis (Henle[22]) (Fig. 536). Surrounding the tendon of the long head of the biceps in the groove of the humerus. Constant. Always communicates with joint cavity, and should be considered as a diverticulum of the capsule.

B. infraspinata (Rosenmüller). Between upper edge of infraspinatus and scapular spine (2 in 3, Synnestvedt).

B. subtendinea infraspinata. Between tendon of infraspinatus and capsule (4 in 14, Synnestvedt).

B. subtendinea teretis minoris (Gruber). Under the tendon of the teres minor. Rare.

B. subtendinea teretis majoris (Fig. 536). Between the tendon of insertion of the teres major and the latissimus dorsi. Constant.

B. subtendinea latissimi dorsi (Fig. 536). Between the tendon of the latissimus dorsi and the humerus.

B. subtendinea pectoralis majoris. Between tendon of pectoralis major and B. intertubercularis + tendon of latissimus dorsi (4 in 12, Synnestvedt).

B. intermuscularis pectoralis majoris (Synnestvedt). Between the clavicular and thoracic portions of the muscle.

ELBOW.—*B. radio-bicipitalis* (Rosenmüller). Between the tendon of the biceps and the inner surface of the radius. Constant, often double.

B. ulno-radialis (Jancke). Between the tendon of the biceps + radial tuberosity and outer surface of ulna + muscles of that region. Of considerable size. Frequent (1 in 4, Gruber; 3 in 6, Synnestvedt).

B. subtendinea brachialis antici. Between the tendon of insertion of the brachialis anticus and the coronoid process. Rare. The older anatomists (Fourcroy, Jancke, Koch) describe a bursa between the brachialis anticus and the interosseous ligament.

B. flexoris digitorum sublimis (Gruber). In the tendon of origin of the flexor sublimis, or between it and the pronator radii teres. Very rare (1 in 200).

B. palmaris longi. Between the origin of the muscle and the joint capsule. Very rare.

B. subcutanea olecrani (Camper). Between the skin and the periosteum of the olecranon. Constant in adults.

B. subtendinea olecrani. Above the olecranon, and in front or at the side of the triceps tendon. Frequent (3 in 5); constant in old subjects.

B. intratendinea olecrani. Within the tendon of the triceps. Quite frequent (7 in 12, Synnestvedt).

B. humero-tricipitalis. Between the anterior surface of the triceps and the fat covering the lower end of the humerus. Rare (1 in 12, Synnestvedt).

B. retro-epitrochlearis. Between the triceps + ulnar nerve behind, and the posterior surface of the internal condyle + median surface of capsule in front. Very rare.

B. anconei (Rosenmüller). Between the anconeus and the capsule (1 in 4 or 5). May communicate with B. extensoris carpi ulnaris or with joint (Henle).

B. epicondyli (Schreger). Between the skin and the external condyle of the humerus. Rare (1 in 60).

B. extensoris carpi ulnaris (Jancke). Under origin. May extend under the extensor communis. Frequent (1 in 3 or 4). May communicate with the joint and also with B. anconei.

B. extensoris carpi radialis brevioris (Monro). Between the common origin of the extensor carpi radialis brevior + the extensor communis digitorum and the head of the radius (1 in 6 or 7).

B. epitrochlei (Schreger). Between the skin and the inner condyle of the humerus. Rather frequent (1 in 5).

WRIST AND HAND.—*B. ulnaris subcutanea.* Over styloid process of ulna. Not constant (3 in 11, Synnestvedt).

B. radialis subcutanea. Over styloid process of radius. Rather rare.

B. dorsalis carpiea subcutanea. Schreger found this in 2 cases.

B. vaginalis extensoris carpi ulnaris (Fig. 537). A small sheath. Reaches to the base of metacarpale V.

B. v. extensoris minimi digiti (Fig. 537). A small and separate sheath.

B. v. extensorum communis et indicis (Fig. 537). Large. Extends farther toward the fingers on the ulnar side.

B. v. extensoris longi pollicis (Fig. 537). Runs obliquely across the next.

B. v. extensorum carpi radialorum (Fig. 537). In groove on back of radius. Single above, divides below.

B. subtendinea extensoris carpi radialis longioris. Under the tendon at its insertion into metacarpale II. (4 in 20, Synnestvedt).

B. subtendinea extensoris carpi radialis brevioris. Under the tendon at its insertion into metacarpale III. (18 in 20, Synnestvedt).

B. vaginalis abductoris longi et extensoris brevis pollicis (Fig. 537).—Surrounds these tendons from the dorsal surface of the radius to the outer edge of the wrist.

B. subtendinea flexoris carpi ulnaris (Fig. 538). Under the tendon at its insertion into pisiform (6 in 30 Synnestvedt).

B. tendinosa ulnaris (Michon) (Fig. 538). The usual arrangement of this extensive sheath is to surround the tendons of both the superficial and deep flexors as they lie in the wrist and palm, sending a diverticulum downward upon the tendons of the little finger. Schüller[23]

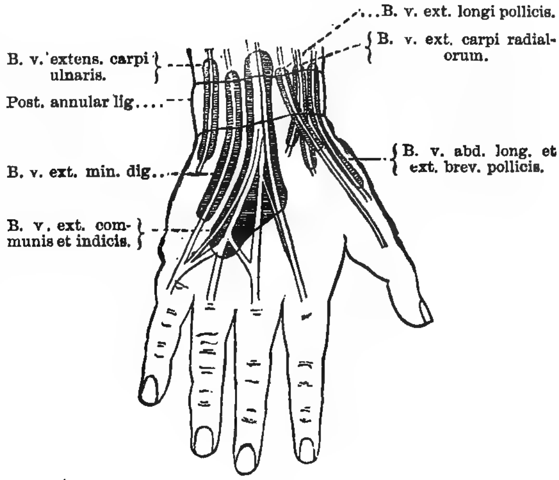

FIG. 537.

describes this bursa as double, the sheath for the tendons of digits IV. and V. being separate from those of digits II. and III. Holden[24] reports a case in which this bursa communicated with the wrist-joint. It does not usually communicate with the radial bursa,[25] but many varieties are found.[26]

B. vaginalis flexoris carpi radialis (Fig. 538). In the groove of the trapezium.

B. tendinosa radialis (Michon) (Fig. 538). Extends from an inch above the anterior annular ligament to the base

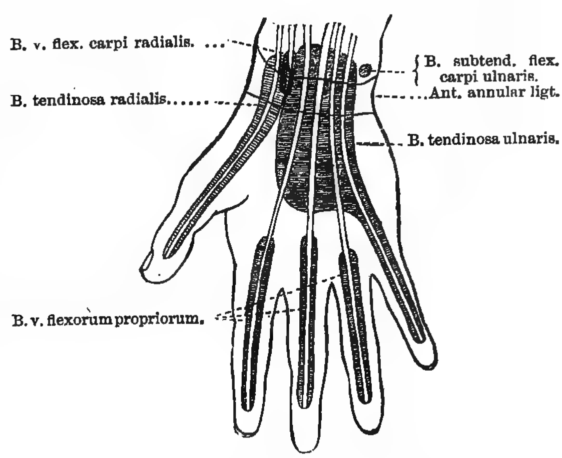

FIG. 538.

of the second phalanx of the thumb, upon the tendon of the flexor longus pollicis.

Bb. dorsales subcutaneæ. Between the skin and the extensor tendons on the ulnar side over the metacarpo-phalangeal joint (Synnestvedt found them in digit I., 40 per cent.; digit II., 53 per cent.; digits III., and IV., 66 per cent.; digit V., 27 per cent.).

Bb. dorsales subtendineæ.—Between the tendons and the capsules of the metacarpo-phalangeal joints. Quite constant. Frequently communicate with joint. When not

found a diverticulum of capsule takes the place (Theile, Synnestvedt).

Bb. volares articuli metacarpo-phalangei. Between the skin + subcutaneous fat and the flexor tendon with its fibrous sheath. Found by Schreger in all the digits, by Synnestvedt only in digits I., II., and III.; most frequent in digit III.

Bb. volares phalangis primæ. Between the skin and subcutaneous tissue and the flexor tendon with its sheath in front of the first phalanx. Found by Synnestvedt in but two instances, in digit II., and digit III.

Bb. vaginales flexorum propriorum (Fig. 538). Special sheaths for the flexor tendons of digits II., III., and IV.

Bb. intermetacarpo-phalangea. Between the heads of metacarpales II., III., IV., and V.

Bb. interossea. Between the tendons of the interossei muscles and the metacarpo-phalangeal joints. Gruber[27] finds two sets of these, one under the part of the tendon that extends to the dorsal aponeurosis, the other under the part which communicates with the phalanx.

B. metacarpea ulnaris (Synnestvedt). Between the skin and the head of the fifth metacarpal. Found in 8 out of 15 cases.

Bb. phalangea dorsales. Over the articulations. Quite constant over the first series; less so over the second.

HIP.—*B. iliaca anterior.* Subcutaneous over the anterior superior spine of the ilium.

B. subiliaca (Hyrtl). Under the tendon of the ilio-psoas, covering the ilio-pectineal tubercle, the anterior surface of the pubes, and the capsule of the hip-joint. This large and constant bursa is sometimes multilocular and frequently (6 in 14, Synnestvedt) communicates with the hip-joint.

B. subtendinea iliaci. Between the tendon of insertion of the ilio-psoas and the femur. Not constant.

B. subtendinea pectinei. Between the insertion of the pectineus and the femur + lowest fascicles of the iliacus. Frequent (8 in 14, Synnestvedt).

B. trochanterica superficialis. Subcutaneous over the trochanter major. Usually small, but sometimes multilocular. Rather frequent (4 in 13, Synnestvedt).

B. trochanterica profunda. Between the tendon of the gluteus maximus and the posterior and external portions of the great trochanter. Large and constant; frequently multilocular.

Bb. gluteo-femorales. One or more between the tendon of the gluteus maximus and the femur. Quite constant.

B. gluteo-fascialis. Between the tendon of the gluteus maximus and the origin of the vastus internus. Constant.

B. glutei medii anterior. Between the anterior portion of the tendon of the gluteus medius and the great trochanter. Nearly constant (12 in 15, Synnestvedt).

B. glutei medii posterior. Between the posterior portion of the tendon of the gluteus medius and the pyriformis. Usual (10 in 15, Synnestvedt).

B. glutei minimi. Between the gluteus minimus and the anterior surface of the great trochanter. Large and nearly constant (14 in 15, Synnestvedt).

B. supra-acetabularis. Between the reflected tendon of the rectus and the upper edge of the acetabulum (5 in 16, Synnestvedt).

B. pyriformis. Under the distal insertion of the muscle. Infrequent (3 in 12, Synnestvedt).

B. gemellorum (Synnestvedt). Between the gemelli and the joint capsule. Found once only. It communicated with B. circumflexa.

B. ovalis obturatoris interni. Between the tendon of the obturator and the gemelli. Rather frequent (5 in 13, Synnestvedt). Communicates sometimes with B. circumflexa.

B. circumflexa obturatoris interni. Between the muscle and the lesser sciatic notch.

B. subtendinea obturatoris interni. Between the tendon and the capsule of the hip-joint. Rare. May communicate with last (Quain).

B. obturatoris externi (Synnestvedt). Between the obturator externus and the joint capsule. Infrequent (2 in 18).

B. quadrati femoris. Between the quadratus femoris and the trochanter minor + tendon of ilio-psoas. Constant.

B. subcutanea tuberis ischii. This is described by some (Hyrtl, Nélaton) as directly under the skin over the tuberosity of the ischium. It is probably rare. The three following are often mistaken for it:

B. musculi glutei in tubere ischii. Between the lower border of the gluteus maximus and the tuberosity of the ischium (5 in 12, Synnestvedt).

B. semitendinoso-bicipitalis in tubere ischii. Between the tendon of the united semitendinosus and biceps and the tuberosity. Constant.

Bb. semi-membranosæ in tubere ischii. Two of these are found between the tendon of the semimembranosus and the quadratus femoris. One is quite constant (9 in 12), the other infrequent (2 in 12, Synnestvedt).

B. iliaca posterior. Subcutaneous over the posterior superior spine of the ilium.

KNEE.—*B. condyli interni;*

B. condyli externi. Subcutaneous bursæ over the projecting condyles (Figs. 539 and 540).

B. præpatellaris subcutanea (Fig. 539). In the subcutaneous connective-tissue in front of the patella. This is quite common (18 in 20, Synnestvedt; 165 in 400, Gruber),

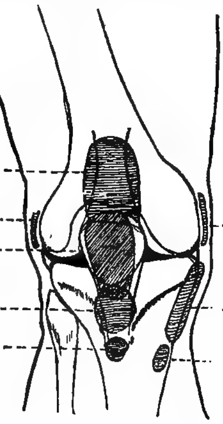

FIG. 539.—The Principal Bursæ in Front of the Knee.

and is usually confounded with the next. It may be of considerable size.

B. præpatellaris subfascialis. Between the fascia in front of the patella and the aponeurosis of the extensors. Not so frequent (9 in 20, Synnestvedt; 23 in 400, Gruber).

B. præpatellaris subaponeurotica. Between the aponeurosis and the anterior surface of the patella. Found in 9 out of 20, Synnestvedt; 23 in 400, Gruber; 10 out of 12, Schreger. This division of the præpatellar bursæ is that of Gruber. The three here described rarely coexist, and when they do, they usually communicate.

B. subcruralis (Fig. 539). Between the tendon of the extensor quadriceps and the lower part of the anterior surface of the femur above the patella. This is always present, and invariably communicates with the joint, except occasionally in very young children.

B. intermuscularis extensoris cruris. Between the tendons of rectus and the cruræus. About an inch above the patella. Rare (2 in 55, Synnestvedt).

B. patellaris lateralis externa. Between lateral expansions of the tendons of the quadriceps femoris and the patella. Rare.

B. patellaris lateralis interna. In a similar situation on the inner side. Synnestvedt mentions two varieties, one superficial and one deeper.

B. præligamentosa. Between the fascia and the ligamentum patellæ. (Found by Synnestvedt in 6 out of 15.)

B. prætibialis (Fig. 539). Between the fascia and the tuberosity of the tibia. Usual in old subjects.

B. subpatellaris (Fig. 539). Between the ligamentum patellæ and the anterior surface of the tibia. Constant

and large. May occasionally communicate with the joint, though Synnestvedt has never seen this, and thinks the reported cases erroneous.

B. subtendinea sartorii. Between the tendon of the sartorius and the internal condyle of the femur. Rather rare (2 in 15, Synnestvedt).

B. sub ligamento interno (Synnestvedt). Between the internal lateral ligament and the capsule (11 out of 21).

B. tibialis interna (Fig. 539). Between the expansion of the lower internal ham-string tendons (semitendinosus, gracilis, sartorius), and the long internal lateral ligament.[28] Constant. It occasionally blends with B. gastrocnemialis interna, and through that communicates with the joint.

B. tibialis subcutanea (Schreger). Subcutaneous over upper end of tibia. Not found by Gruber or Synnestvedt.

B. tendinis poplitea. Between the external lateral ligament and the tendon of the popliteus. Not constant (5 in 16, Synnestvedt). Occasionally communicates with joint.

B. tendinis bicipitis (Fig. 540). Between the external lateral ligament and the tendon of the biceps. Nearly constant (21 in 26, Synnestvedt; 191 in 200, Gruber). It occasionally communicates with the joint. The external popiteal nerve is in relation to it.

B. subtendinea tensoris fasciæ laiæ (Synnestvedt). Between the ilio-tibial band and the capsule. Found in 3 out of 19, once communicating with joint.

B. fibularis subcutanea (Schreger). Subcutaneous over upper end of fibula. Not found by Gruber or Synnestvedt.

B. supracondyloidea interna (Fig. 540). Between the

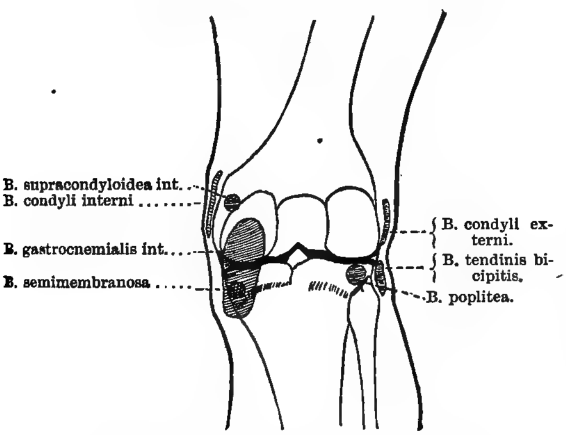

FIG. 540.—The Principal Bursæ behind the Knee.

inner tendon of the gastrocnemius and the femur. Nearly constant. May communicate with joint.

B. gastrocnemialis interna (Figs. 539 and 540). Between the inner head of the gastrocnemius and the semimembranosus. It is behind the internal condyle and over the neighboring capsule. Large and constant. Sometimes multilocular. In adults it usually communicates with the joint. Synnestvedt describes the lower part of this as a separate bursa, under the name of *B. semimembranoso-gastrocnemialis.*

B. semimembranosa (Fig. 540). Between the expansion of the semimembranosus tendon and the inner condyle of the tibia. Usually closed. Constant.

B. gastrocnemialis externa. Between the external head of the gastrocnemius and the capsule. Rare.

B. bicipito-gastrocnemialis. In the popliteal groove between the prominence of the sesamoid bone in the head of the gastrocnemius and the biceps tendon. Very rare.

B. poplitea (Fig. 540). Between the popliteus and the joint capsule + external tuberosity of tibia. This always communicates with the joint, and is properly a diverticulum of the capsule, occasionally (1 in 10, Lenoir) it also communicates with the cavity of the superior tibio-fibular articulation.

ANKLE AND FOOT.—*B. malleoli externa;*

B. malleoli interna. Subcutaneous over the malleoli. Not constant. External more frequent.

B. vaginalis extensoris longi digitorum;

B. v. extensoris longi hallucis;

B. v. tibialis antici (Fig. 541). Around the tendons of these muscles. Not infrequently the sheath of the ex-

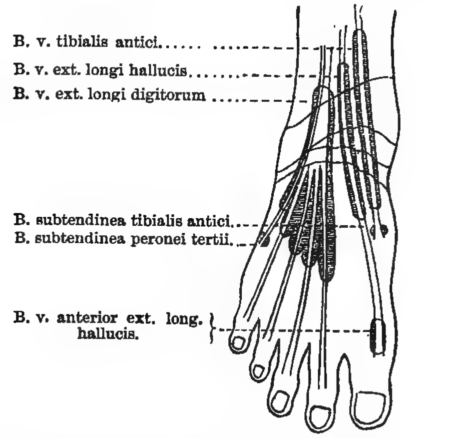

FIG. 541.—Synovial Sheaths on Back of Ankle and Foot.

tensors extends somewhat higher up than is shown in the figure.

B. sinus tarsi (Gruber). Between the fascia which binds down the extensor longus digitorum and the head of the astragalus. Quite frequent (5 in 12, Synnestvedt; 97 in 174, Gruber). May communicate with joint.

Bb. sub musculo pediæo. Under the extensor brevis digitorum. Usually two. Found by Synnestvedt 2 in 16.

B. tarsiea subcutanea (Schreger). On dorsal surface of foot.

B. vaginalis tibialis postici (Fig. 542). Surrounds the tendon as it lies back of the internal malleolus.

B. v. flexoris longi digitorum;

B. v. flexoris longi hallucis (Fig. 542). Surround the tendons behind the internal malleolus and extend into the sole.

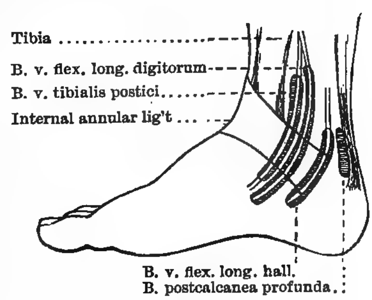

FIG. 542.—Synovial Sheaths of Inner Side of Foot.

B. postcalcanea superficialis. Between the tendon and the deep fascia. Not constant.

B. postcalcanea profunda (Fig. 542). Between the tendon and the posterior surface of the calcaneum. Constant. Has cartilage on two of its walls, viz., over the bone, and a thin layer coating the anterior surface of the tendon.

B. subcalcanea (Lenoir[29]). Between the inferior surface of the calcaneum and the plantar fascia. Constant.

B. subtendinea tibialis antici (Fig. 541). Under the tendon at its insertion upon cuneiforme I. (5 in 12, Synnestvedt).

Bb. abductoris minimi digiti (Synnestvedt). One between the abductor and the sesamoid bone of the peroneus longus; another between the muscle and the tuberosity of metacarpale V. Rare.

B. subtendinea peronei tertii (Hyrtl) (Fig. 541). Under the tendon at its insertion upon head of metacarpale V. Not constant.

B. subtendinea extensoris longi hallucis. Between the

tendon and the head of metacarpale I. Small and rather rare.

B. vaginalis anterior extensoris longi hallucis (Fig. 541). Over metatarso-phalangeal joint I. About one inch long.

B. v. peronei. Sheathes the peroneal tendons behind the external malleolus. Single in the middle, it divides above and below.

Bb. dorsales subcutaneæ. Several of these are described by Schreger and Synnestvedt. One over cuneiforme I., one over head of metacarpale I., and occasionally over other projections.

Bb. dorsales subtendineæ (Synnestvedt). These occur in similar situations as those of the hand, and agree with them in form and size.

B. vaginalis peronei longi. Sheathes the tendon as it lies in the groove of the cuboid. A small bursa is sometimes found under the tendon where it turns around the outer side of the cuboid, and another under its insertion upon metatarsale I.

Bb. plantaris metatarso-phalangei (Schreger). These occur at the articulations.

B. plantaris in capitulo ossis metatarsi I. (Lenoir);

B. plantaris in capitulo ossis metatarsi V. (Lenoir). These are well-known bursæ between the skin and the points of greatest pressure.

Bb. intermetatarso-phalangeæ. These are usually found in old subjects, between the toes, in the region of the metatarso-phalangeal joints. The three inner are most constant (No. 1, 95 per cent.; No. 2, 98 per cent.; No. 3, 95 per cent.; No. 4, 28 per cent., Gruber). Occasionally communicate with joints.

Bb. interossea. Between the interossei and the metatarso-phalangeal joint. Rarely communicate.

Bb. lumbricalium. Under the lumbricales and laterally to them. Rare.

B. abductoris minimi digiti. Between the abductor of the little toe and the head of metatarsale V. Rare (1 in 14, Synnestvedt).

Bb. phalangea dorsales (Schreger). These are not so constant as those of the hand.

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Frank Baker.

[1] See White: American Journal of the Medical Sciences, January, 1884.
[2] Mém. de l'Acad. de Méd. Paris, xvi., 391; cf. Cornil and Ranvier, Manuel d'Histologie Pathologique, 2d ed., i., 354.
[3] Hyrtl: Oest. Zeitsch. f. pract. Heilk., vii., 47, 1861.
[4] Rodrigues: Annal. d'Ocul., Juillet, 1845.
[5] Topogr. Anatomie, 7 Aufl., i., 225. [6] Op. cit., i., 415.
[7] Op. cit., i., 363. [8] Häser's Report, ii., 6, 1841.
[9] Sappey: Anat. Descriptive, 2d ed., iv., 67.
[10] Tillaux: Anatomie Topographique, 3d ed., 320. Cf. C. O. Weber in Virchow's Archiv, vi., 511, Berlin, 1854.
[11] Richet: Anat. Medico-Chirurg., 3d ed., 393.
[12] Luschka: Anat. des menschl. Halses, 140.
[13] Archiv für Anat. u. Physiol., Leipzig, 1875, 590.
[14] Mem. della Acad. di Bologna, ser. 3, 1874, v., 335.
[15] Henle: Bänderlehre, 2 Aufl., 68.
[16] Gazette des Hôpitaux, Mai, 1854, p. 250. Nancrede cites this with approval.
[17] Luschka: Anat. des menschl. Beckens, Tübingen, 1864, p. 28.
[18] Zeitsch. f. Anat. und Entw., vol. i., 205. 1875–76.
[19] Terrillon: Arch. gén. de méd., Par., 1874, ii., 385–403; also *ibid.*, 1877, ser. 6, xxx., 20–32. [20] Cf. Henle: Bänderlehre, 2 Aufl., 64.
[21] Henle: Muskellehre, 2 Aufl., 182. [22] Bänderlehre, 2 Aufl., 75.
[23] Deutsche Med. Wochenschr., 1878.
[24] Manual of Dissection of the Human Body, 5th ed., 385.
[25] Tillaux: Anatomie Topographique, 3d ed., 568.
[26] See Sappey: Anat. Descr., ii., 334.
[27] Die Bursæ mucosæ der Spatia intermetacarpo-phalangea. St. Petersburg, 1859. [28] Henle: Bänderlehre, 152; Muskellehre, 284.
[29] Recherches sur les Bourses muqueuses sous-cutanées de la plante du pied, etc. Presse médicale, Paris, 1837, i., 49–53.

BUTTER (*Beurre*, Codex Med.). Butter is admitted into the French Pharmacopœia as one of the ingredients of its *Emplâtre brun*, in which it is mixed with olive oil, lard, yellow wax, mutton tallow, pitch, and litharge (!). Sweet, recently prepared butter makes a very agreeable and soothing ointment, but it becomes so quickly rancid and irritating that it is hardly useful, excepting as an *extempore* makeshift. Of course, only unsalted butter is suitable for such purposes. (See LARD.) *W. P. Bolles.*

BUTTERNUT (*Juglans*, U. S. Ph.), *Juglans cinerea* Linn.; Order, *Juglandeæ.* The Butternut is a medium-sized tree, with short, freely branching trunk, and a light foliage of pinnate leaves. The flowers are monœcious: the staminate, in lateral drooping catkins, have an irregularly five- or six-lobed perianth (involucre), and numerous stamens; the pistillate ones are few together, in terminal clusters, with a four-lobed perianth (involucre) adherent to the ovary. The latter is one-celled, one-seeded. Fruit an oval, pointed drupe; the outer part, in drying, breaks irregularly away from the very rough, dark-brown, oblong stone, which is the familiar butternut. It is a widely distributed tree, growing in the middle latitudes of North America, furnishing a useful cabinet wood, edible fruit, and a fair dyeing material.

The bark of the root is officinal. It is, when first removed, white, but rapidly becomes yellow, and then brown, upon exposure. It should be, when dried, "in flat or curved pieces, from an eighth to a quarter of an inch (3 to 6 millimetres) thick; the outer surface nearly free from soft cork; deep brown; the inner surface smooth and striate; transverse fracture short, delicately checkered, whitish and brown; odor feeble; taste bitter and somewhat acrid."

The analyses of Butternut are not satisfactory. Mr. Thiebaud found a volatile crystalline acid in it, which he named *juglandic acid.* It is presumably the same as the yellow *juglon* found by Vogel in the European walnut. No special medicinal principle has yet been separated from it. Tannin is said not to be present. The kernels contain an abundance of bland, but easily rancifying oil.

ACTION AND USE.—Butternut is a mild cathartic, operating, usually, without pain or irritation, well adapted to continuous administration, and worthy more frequent use than is made of it. Dose, one or two grams (1–2 gm. = gr. xv. ad xxx.). An extract, Extractum Juglandis—dose, three to six decigrams (0.3–0.6=gr. v. ad x.)—is the only preparation.

ALLIED PLANTS.—*Juglans regia* Linn., is the European walnut (*Noyer commun*, Codex Med.); its leaves are the *Folia Juglandis* of the German Pharmacopœia; its oil, the walnut oil of the market. The rind of the green fruits is collected and dried for a stomachic and vermifuge. It contains the *juglon* (*nucin*) above mentioned. The leaves are used for "scrofula, rickets," etc.

Juglans nigra, the Black Walnut, has probably similar properties to those of Butternut.

ALLIED DRUGS.—See RHUBARB. *W. P. Bolles.*

BUTYL CHLORAL HYDRATE, $C_4H_5Cl_3O,H_2O$. This substance, formerly erroneously styled *croton chloral hydrate*, was introduced into medicine in 1870 by Liebreich, but has not met with much favor, and failed to secure official recognition in the revision of the U. S. Pharmacopœia of 1880. Butyl chloral hydrate is in the form of colorless crystalline scales, of an odor and taste reminding

of ordinary chloral hydrate. It has the disadvantage, as compared with the latter substance, of being but sparingly soluble in cold water. It dissolves freely in alcohol, in glycerin, and in boiling water.

Butyl chloral hydrate is closely allied, chemically, to ordinary chloral hydrate, and resembles that compound in its effects upon the animal system. Its only recommendation to medical favor lay in its supposed property of being peculiarly anodyne to the trigeminal nerve (Liebreich), and so of peculiar promise for the alleviation of neuralgias of the face and head; but this property certainly does not exist to any marked degree. Practically, the drug is only a comparatively insoluble, and therefore inconvenient, substitute for ordinary chloral hydrate. It may be given in doses ranging from 0.30 to 2.00 Gm. (five to thirty grains) in syrupy mixture. *Edward Curtis.*

CABBAGE, RED (*Chou Rouge*, Codex Med.). Red Cabbage is one of the horticultural varieties of the common cabbage, *Brassica oleracea* Linn., order *Cruciferæ*, and is extensively used as a salad or pickle. It has had some reputation as a "pectoral," etc., but has no medicinal value and is obsolete everywhere, excepting possibly in France, so far as medical use is concerned. Directions for preparing a juice, or *suc*, are in the French Pharmacopœia.

Allied Plants, etc.—For the order Cruciferæ, see Mustard. *W. P. Bolles.*

CACAO, BUTTER OF (*Oleum Theobromæ*, U. S. Ph.; *Oleum Cacao*, Ph. G.; *Cacao*, Codex Med., Seeds). *Theobroma Cacao* Linn.; Order, *Sterculiaceæ*, is the source of Cacao, or, as they are more popularly called, Cocoa seeds. It is a small or medium-sized, quick-growing, South American tree, with soft brown wood and a fine spreading crown, bearing large glossy green leaves, and enormous fruits. The leaves are alternate, simple, ovate or oblong, pointed, entire, and drooping. When young they are conspicuously pink or red. The flowers are in little cymes or solitary, they are axillary, or rather lateral, for they usually grow from the sides of older branches, or even from the trunk itself ("axils of long-departed leaves"). They are small, pink or red, regular and perfect. Calyx spreading, five-parted, lobes lanceolate pointed, petals separate, each dilated at the base into a hemispherical pouch or cup, in which the anthers rest, narrowed above to a long, reflexed, petiole-like middle portion, and expanded at the apex to a broad, short, flat, wedge-shaped blade. Filaments united below in a bell-shaped tube, surrounding, but not adherent to, the ovary, separating above into five upright, narrow, pointed staminodes, alternating with the petals, and five (ten or more united in five sets, Baillon) opposite, strongly recurved stamens, with double or multiple anthers, resting in the above-mentioned pouches of the petals. Ovary five-celled, many-ovuled. Fruit a large (fifteen to twenty-five centimetres long by about half as wide, six to ten by four inches), many-seeded berry, with a rather corky rind and soft mucilaginous pulp. It is oblong, pointed, ten-ribbed, yellow or orange when ripe. The seeds are from two to four centimetres long (three-fourths by one and one-half inch), oblong rounded, slightly compressed, and nearly filled with the thickened embryo. When fresh, they are fleshy in texture and white within, but they become brown, dry, brittle, and fissured with age.

Cacao trees are natives of tropical America from Mexico and the West Indies to Brazil and Peru. They are also cultivated in all these places, as well as in the hotter parts of the old world.

The use of this plant in some parts of America antedates the discovery of the continent by Europeans; Columbus is said even to have observed it. In Yucatan the seeds were a medium of exchange between the native inhabitants, taking the place of money; in Mexico an infusion for drinking was made from the seeds, and a fermented drink from the juice of the fruits; the latter practice was followed in several other countries. The Indians of the Orinoco region ate the pulp of the fruit (which is not disagreeable, although rather insipid), and threw the seeds away. In Brazil, however, where the cacao also grows in abundance, its value was first learned from the white settlers. The seeds were imported into Europe by the early Spanish voyagers, and have continued in constant and increasing use ever since the beginning of the seventeenth century. The fixed oil was separated and brought to notice as an ointment, etc., about one hundred years later. The consumption of chocolate, while not approaching that of tea or coffee, is enormous (amounting to fifty million kilos a year). It is much more used in Spanish and tropical, than in more northern countries, at least as a beverage; as a flavoring material for confectionery and cakes it is everywhere popular.

The cacao of modern commerce is almost entirely the product of cultivated plants, and comes principally from American countries; Mexico and the northwestern parts of South America supplying the finest grades. The varieties are numerous, and generally named from the port or place of export, as Caracas, Guatemala, Esmeralda, etc. It is collected and prepared in different ways. Sometimes, as in Brazil, Pará, St. Domingo, etc., the seeds are mechanically separated from the rest of the fruit and quickly dried; these more natural seeds are cleaner and lighter colored than those prepared by what is termed "rotting," but being more bitter and less agreeable, consequently sell at a lower price. "Rotting," which is the process used in these countries which produce the most valued sorts, consists in roughly sifting or rubbing out the seeds, and then putting them for a day or two in heaps covered with leaves, or in tubs, or even burying them under the ground until decomposition of the surrounding pulp takes place, then they are quickly dried like the others. The process is said to deprive them of a portion of their bitterness and develop their aroma. They are darker colored than the seeds which have not been "rotted," and usually have vestiges of the soil with which they have been in contact upon their surface. Cacao, like coffee, improves in flavor with age.

Constituents.—The thin, brittle testa easily separates from the embryo which constitutes the kernel; it composes about one-eighth of the weight of the seed, and, when prepared, is the "shells" of the grocers. It contains, in a lower degree, the alkaloid and flavoring matters of the kernel, and, besides, a considerable proportion of mucilage, in part, probably, derived from the fruit. The kernels themselves contain nearly half their entire weight of *fixed oils*, the so-called *butter of cacao*, or, as it is more generally named in this country, "cocoa butter." This is a solid, cream-colored fat, of pleasant odor and bland, chocolate-like taste; hard, brittle when cold, but melting readily a little below the temperature of the body; specific gravity, 0.900 to 0.910. It is composed of the glycerine compounds of several common fatty acids: oleic, palmitic, stearic, lauric, and arachic, according to Traub. Kingzett believed that he had found a peculiar fat, to which he gave the name theobromic acid, but its existence is not fully verified. Butter of Cacao is expressed upon a large scale by the chocolate manufacturers as a by-product in the preparation of their "chocolates" and "cocoas," and is usually found in the shops in the United States in flat rectangular cakes of about a half pound each. A feeble alkaloid, *theobromine*, related to caffeine, and discovered by Woskresensky in 1845, exists in Cacao seeds to the extent of from one to four per cent. It is a white, crystalline powder, with a slowly developing, bitter taste, but no odor. It is remarkably insoluble in all the usual pharmaceutical liquids—water, alcohol, ether, chloroform, etc.—when cold; at a high temperature it can be sublimed without decomposition. With the mineral acids it forms crystalline, but not very stable salts. Theobromine has been produced by synthesis from "xanthine," and it has also been made to yield caffeine by decomposition. A small amount of *caffeine* is observed in Cacao, along with the theobromine. The other constituents are *starch*, ten or more per cent. "*cocoa-red*," two per cent. a brown nitrogenous substance, mucilage, etc. The aromatic principle needs further study.

ACTION AND USE.—The alkaloid *Theobromine* is similar in its physiological properties to Caffeine, but far weaker; it is never used in medicine, and the amount present in the ordinary preparations of Cacao is too small to give them any medicinal action. The "butter" has the usual qualities of the simple edible oils; it is an acceptable, non-nitrogenous article of food, and as an external application it is an efficient, protective ointment. It is considerably used for chapped lips or hands; for anointing the body in scarlet fever and other exanthemata. As a palliative in acute pharyngitis, a piece melted in the mouth occasionally gives a little relief. The most extensive medical use of it, however, is as the basis of suppositories and medicated bougies, for which its hardness, its melting-point, and its remarkable unalterability peculiarly adapt it; for this purpose it is melted and the medicament added just before it congeals again, the mixture is then poured into suitable moulds. In writing a prescription for these preparations, the amount of the excipient should be so adjusted as to make each rectal suppository weigh about one gramme; vaginal suppositories are about twice as large. The moulds, however, in which suppositories are usually made in the United States vary, and it is generally better to direct *Olei Theobromæ, quantum sufficiat,* when the apothecary will add enough to fill his mould or machine.

The dietetic preparations of cocoa have no medicinal significance. "Shells" make a drink which is scarcely more than a flavored water; the different so-called cocoas are nutritious in proportion to the amount of oil which they contain, and according as they are ground fine and drunk in substance, or coarse and strained out of the drink. Chocolate consists of the kernels ground to a fine paste, and pressed into cakes. It is often flavored with vanilla or cinnamon, and generally sweetened; it contains more oil than the preceding, and is consequently more valuable as food, when it can be taken without deranging the digestion. Chocolate makes a good excipient or pill coating. Besides the above, manufactured cocoas and chocolates are sold under various proprietary and fanciful names. For all the above purposes the seeds are lightly roasted like coffee; a process which serves to enrich and modify their flavor in some way—the explanation of which is not known. Chocolates and ground cocoas are considerably liable to adulteration; starch, dextrine, and cheaper fats being the most important additions..

ALLIED PLANTS.—There are six species of Theobroma, all of them American shrubs, most of which contribute to the yield of Cacao, but in what proportion is not fully known. Besides these, the cultivated varieties, as would be expected, are numerous. The order *Sterculiaceæ* is a large one, of mostly tropical plants; few of which have any medical interest. The Cola nuts (*Stercula*), so largely consumed in Africa, belong to it; they contain caffeine and also theobromine. By some botanists *Theobroma* is placed among the *Malvaceæ*.

ALLIED DRUGS.—For the drugs containing CAFFEINE, see references in that article. For the vegetable oils and fats, see OLIVE OIL. A mixture of gelatine and glycerine, or of gelatine and water, is occasionally used as a suppository basis. *W. P. Bolles.*

CADE, OIL OF (*Cade, Huile de,* Codex Med.). A tar obtained by the distillation of *Juniperus Oxycedrus* Linn.; Order, *Coniferæ,* and perhaps also of other species of *Juniperus.*

J. Oxycedrus resembles in general the common Juniper of Europe, but has larger, reddish-brown, shining fruits (one and one-fourth centimetre in diameter—one-half inch). It is an inhabitant of the Mediterranean basin (Southern Europe, Northern Africa, etc.) growing in waste places and stony hillsides.

This tar has been used for centuries by the peasants of Southern France for the "sheep itch" and other cutaneous affections of their cattle, but its employment in medicine, although occasional and also of old date, has only been extensive since its recommendation by the German school of dermatologists in the treatment of eczemas. It is prepared by a method similar to that used in the manufacture of ordinary tar; that is, by distillation, *per descensum,* in rude stills or ovens, from the bottom of which it is collected and then sold without further purification. The principal centre of its production is Nîmes.

Oil of Cade is, singularly, not officinal in the United States, although in everyday use. It is a thin tar, black in mass, but brown or brownish-yellow and transparent, in thin layers; and is more fragrant and pleasant in odor than common wood-tar, which it otherwise resembles. Taste is acrid and empyreumatic. Its composition is not notably different from that of the tars of other conifers. The principal use to which it is put in medicine is that mentioned above—for the local treatment of eczema in the scaly stage. It is also used in other chronic inflammatory and exfoliating skin diseases. It may be applied by rubbing in with the fingers or a cloth, or what is better, with a stiff-haired brush. If desirable to dilute it, some bland oil may be mixed with it, or it may be made into an ointment with lard or tallow, or with vaseline. Soaps containing it are also considerably used. Stockings, gloves, and bandages saturated with it are sometimes worn. Besides its stimulating properties, Oil of Cade is a good parasiticide, an efficient antiseptic, and a local anæsthetic; properties which it undoubtedly owes to the creasote and similar substances which it contains. It is never used internally.

ALLIED PLANTS.—*Juniperus communis* Linn., the common Juniper of Europe, probably contributes sometimes to the manufacture of Oil of Cade. It yields a substance very similar. (See TURPENTINE, for Order *Coniferæ.*)

ALLIED DRUGS.—All tars: Birch, Beech, Pine, etc. Oil of Cade is thinner, pleasanter, and milder than common tar; otherwise it is not much different. Balsam of Peru is a somewhat similar substance, but less stimulating. Chrysarobin, also used as an irritant in dermatological practice, is very much more harsh in its action.

W. P. Bolles.

CADMIUM. *Cadmium Sulphate* is the only salt of this metal that merits notice in medicinal relation. It was officinal in the U. S. Pharmacopœia of 1870, and, though dropped in the revision of 1880, is still considerably employed. The salt, formula $CdSO_4,4H_2O$, occurs in small, colorless, rhomboidal crystals, efflorescent on exposure. It is freely soluble in water, and has a subacid and astringent and metallic taste. In properties it most closely resembles zinc sulphate, being an astringent irritant with, given internally, a special emetic tendency. Its claim for recognition in medicine rests on an alleged peculiar potency in determining the absorption of such corneal opacities as are capable of undergoing the process —a potency certainly not much, if at all, greater than that possessed by the commoner salts, nitrate of silver or sulphate of zinc.

Cadmium sulphate is generally used in solution of from one-half to one per cent. strength. *Edward Curtis.*

CADMIUM, POISONING BY. Cadmium and its salts are comparatively unimportant from a medico-legal point of view. Their uses are limited, and they are seldom met with outside of the chemical laboratory. The metal is employed occasionally in alloys to reduce their fusing-point, and an amalgam has been used by dentists for filling teeth. The most important compounds are the iodide and bromide, which are used in photography for iodizing and bromizing collodion. The sulphate of cadmium has been recommended, used internally, in the treatment of syphilis, rheumatism, and gout (Grimaud). It has been chiefly used externally, however, as an astringent and stimulant, in the treatment of conjunctivitis, and ulcers and opacities of the cornea. The iodide of cadmium, in the form of an ointment, has been recommended for external use, particularly in the treatment of scrofulous enlargement of the glands (Garrod, Guibert). The sulphide of cadmium has been used, to a limited extent, as a yellow pigment. Excepting the sulphide, the compounds mentioned are colorless, soluble in water, and possess a disagreeable metallic taste.

SYMPTOMS.—Preparations of cadmium have given rise, occasionally, to accidental poisoning. They appear to act as irritants, resembling in general the salts of zinc. Sixty milligrammes (0.9 grain) of the sulphate, taken internally, caused in one hour salivation, colic, and diarrhœa; and after four hours, vomiting accompanied by intense gastralgia and tenesmus (Burdach). Vomiting, diarrhœa, vertigo, labored respiration, loss of strength, and cramps followed the inhalation of the dust arising from a polishing powder containing carbonate of cadmium (Sovet). Two ladies took an uncertain but small dose of bromide of cadmium by mistake for bromide of ammonium. It caused severe pain and a burning sensation in the stomach, accompanied by vomiting and purging which lasted for five hours. During a part of this time the pulse was imperceptible. There were no cerebral symptoms. Both patients were confined to their beds for several days, during which time their stomachs continued irritable (Wheeler). There is only one fatal case of cadmium poisoning recorded, so far as the writer has been able to learn. The patient, a lad fourteen years of age, took an unknown but probably large dose of chloride of cadmium, which had been sold for Epsom salts. It caused immediate vomiting. On admission to the hospital a short time after, he was in a state of collapse, with cold, clammy skin; radial pulse scarcely perceptible; respiration feeble, slow, and sighing. There was no stertor. The mucous membrane of the mouth was pale and sodden, the tongue greatly swollen. He was apparently unconscious, though when shaken and aroused by dashing cold water upon the face, he replied rationally, in a hoarse whisper, to any questions put to him. There was extreme restlessness. Deglutition was impeded. Death took place in about an hour and a half after the ingestion of the poison. At the post-mortem examination the vessels of the brain were found filled with blood; the left lung congested (Mr. J. Hinder: *The Indian Medical Gazette*, Calcutta, 1866, i., 156).

EXPERIMENTS ON ANIMALS.—Marmé has studied the action of the salts of cadmium by experiments on animals. He concludes that the sulphide is non-poisonous. Administered to animals with their food for a week, in doses of many drachms, it caused no inconvenience. Its insolubility in water, weak acids, alkaline salts and oil, renders its use as a pigment free from danger. All compounds of cadmium which are soluble in water or weak acids at the temperature of the body are poisonous. Taken into the stomach they cause, in small doses, vomiting; in large doses, all the symptoms of gastro-enteritis. If quantities sufficiently large to be poisonous, without causing death rapidly, are injected beneath the skin or into the blood-vessels, they produce inflammation of the stomach and intestines, and frequently hæmorrhages, erosions, and ulcerations. Small doses injected into the blood-vessels are fatal to animals. Thirty milligrammes (0.5 grain) killed a dog; sixteen milligrammes, a cat; ten to twenty milligrammes, a rabbit. Thirty to sixty milligrammes (0.5 to 0.9 grain), administered by the mouth, killed a rabbit weighing 1,500 to 1,800 grammes (3.3 to 3.9 pounds avoir.). The repeated absorption of small doses may give rise to chronic poisoning, which, in animals, is characterized by disturbed digestion, emaciation, and death. The post-mortem appearances observed were, a more or less extensive gastro-enteritis, sometimes subpleural hæmorrhages, infarctions of the lungs, frequently fatty degeneration of the liver and heart, and diffuse nephritis. Elimination commences very soon and takes place chiefly through the kidneys. After death cadmium can be detected in the blood, heart, liver, and kidneys.

TREATMENT.—This should be much the same as in cases of poisoning by salts of zinc. Vomiting should be assisted, if necessary, by the free administration of warm water, with milk or mucilaginous liquids; or the stomach may be emptied by means of the stomach-pump. The subsequent irritation may be allayed by the use of opium. Marmé recommends, in cases of acute poisoning, the alkaline carbonates with white of eggs. The subcutaneous injection of dilute solutions of soda, when employed early, was found, in the case of animals, to completely arrest the poisonous action of the cadmium salts.

William B. Hills.

CÆCUM AND APPENDIX, DISEASES OF. The cæcum is the large intestine into which the ileum opens. There is no line between it and the colon, the division being arbitrary; yet it is accepted for convenience of description that the ileo-cæcal opening marks the commencement of the ascending colon; this would leave between two and three inches of bowel in length to bear the name of cæcum.

The cæcum has a larger diameter than any other portion of the intestine, in that respect being second to the stomach only. It occupies the right iliac fossa, being joined by connective-tissue to the fascia over the iliacus muscle. This connective-tissue is extremely lax, permitting much motion. The cæcum is covered partly by peritoneum, which, surrounding it more or less completely, binds it, through the medium of connective-tissue, to the iliac fascia. This disposition of the serous membrane varies greatly in different individuals, sometimes forming a distinct meso-cæcum, allowing as a sequence great motion to the bowel; at other times the peritoneum is reflected over the anterior and inner aspect of the bowel only, and permits but limited movement.

The cæcum when distended touches the anterior abdominal wall; when collapsed some loops of small bowel usually overlie it. It is not easy to state the diameter of this portion of the large bowel in inches, owing to its variable fulness, but it is considered as being about as broad as it is long. Toward the middle line of the body, on its left side, the cæcum receives the termination of the small bowel, while below, and somewhat behind, the vermiform appendix opens into it.

The coats of the cæcum correspond to those of the colon, indeed they are the same—the same disposition of circular fibres, and the same arrangement of longitudinal bands, with the resulting pockets. The internal surface is lined with mucous membrane, continuous with, and similar to, that of the colon, and shows two openings where the small bowel and appendix respectively connect with the great gut. The former of these apertures is slit-like in shape, and opens at the summit of a ridge dividing two pockets; hence, distention of the cæcum draws together the sides of the slit and tends to prevent regurgitation from the large to the small intestine. For full details the reader is referred to an anatomical treatise, but it is worth while recalling to mind that while the longitudinal muscular fibres are continued directly from the small to the large bowel, the circular fibres are not, and that the opening of the ileum at the summit of the ridge already mentioned results in a partial invagination of the small into the great bowel. After the peritoneum and longitudinal muscular fibres have been cut, traction upon the ileum causes the protrusion into the cæcum to disappear, and the ileo-cæcal joining is seen to be a round hole with no valvular appearance whatever. The protrusion of the circular fibres of the ileum into the cæcum normally, is offered as one of the reasons why intussusception so commonly commences at this point. The possibility of regurgitation through the ileo-cæcal valve has been much discussed, and, as with human affairs generally, no hard and fast rule can be laid down. In a series of investigations undertaken some years since, I found great differences to exist in different intestines, not only when *in situ* but also after removal from the cadaver. In some cases thickish fluid was passed through the valve under moderate pressure, while in others I ruptured the large bowel with air pressure, the untied ileum remaining empty, so complete was the closure of the valve.

The vermiform appendix varies in length from two to six inches, is about the diameter of a goose quill, is hollow through its entire length and opens into the cæcum, as has been said, at its lower and posterior aspect. The unattached extremity is blunt; a fold of peritoneum surrounds the appendix and connects it with neighboring parts. This fold may be so lax as to form a mesentery. The position of the appendix is extremely variable, as is

also that of its attachment. It has been seen at one time adhering to the liver, and at another to the testes by way of the inguinal canal; it has also been known to extend across the abdominal cavity, and it may become knotted around other portions of the alimentary canal, producing strangulation. A fold of mucous membrane extends partially over the opening of the appendix into the cæcum. It is customary to dignify it by the name of valve. We are unable to attribute to the appendix any function. While it is found in man and a few apes, in certain other animals, notably the rodents, the cæcum is developed below the valve into a glandular organ many times larger than the stomach, with, of course, an appropriate function.

The cæcum in man, situated as it is below the ascending colon, and having its contents poured in from above, would be expected occasionally to retain substances for a long time, and it is probably true that such is the case, and that by the gradual absorption of the more soluble portion a mass of aliment or excrement may be converted into a concretion of great hardness, which, acting as a foreign body, will set up acute inflammation. In consequence, also, of its dependent situation, the cæcum will receive and retain a foreign body.

Inflammation in the right iliac fossa about the cæcum is not uncommon, and, owing to the extreme rapidity with which a fatal issue may supervene, has received much attention. If the morbid process commences in the cæcum or appendix it is denominated *typhlitis;* if it commences in the connective-tissue joining the bowel to the iliacus muscle, it is denominated *perityphlitis;* sooner or later, however, one of these conditions induces the other, so that it is impossible to draw a hard and fast line between them, nor indeed is it necessary. It is true that rapidly fatal cases occurring without premonition generally commence in the vermiform appendix, while cases characterized by premonitory symptoms and tumefaction in the right iliac fossa are cæcal in origin; yet not always is this the case, unfortunately, and a recognition of the starting-point of the inflammation is often possible only at the autopsy. Inflammation of the cæcal region—typhlitis—is more frequent in men than in women, in the proportion of not less than six to one; it occurs between the ages of sixteen and thirty-five years. The disease may follow either an acute or a chronic course. In the former case great pain characterizes the onset of the trouble, and there may or may not be a chill; then follow fever, vomiting, constipation, meteorism, the development of an exquisitely tender swelling in the right iliac fossa, and, finally, general peritonitis, with probably a fatal result, or else the disease becomes chronic. Such a history would indicate pressure of a foreign body against the intestinal wall, with perforation and escape of intestinal contents into the peritoneal cavity. Should the perforation not be in the direction of the peritoneum, then suppuration in the connective-tissue follows—perityphlitis; or should the extravasation be walled in by adhesions, the resulting abscess may burst secondarily in various directions. A foreign body occasionally remains in the cæcum, but the appendix is much more often its chosen seat; hence such bodies are small. By far the most common object is an intestinal concretion, or mass of fæces from which water has been removed by absorption during its sojourn in the cæcum or appendix. Such masses are more or less hard, and, becoming impacted in the appendix, by gradual and continuous pressure, approach the peritoneum, and suddenly cause ulceration and perforation. Of foreign bodies the seeds of fruits have been often met with; thus, for example, those of oranges, dates, prunes, grapes, raisins, and peaches, have all produced fatal ulceration, while gallstones, bits of bone, worms, beans, shot, pins, together with many other objects, have been noted by different observers. The duration of the affection may vary from a few days to several months, and a permanently impaired condition of the intestine may remain after apparent recovery. Although the acute symptoms may subside rapidly, the function of the bowel is not restored at once, and careful dieting, etc., is to be followed out. Recurrent attacks of inflammation will suggest the presence of a continuously acting cause, and inflammatory induration will often persist after the function of the bowel is restored.

An acute attack may be ushered in without premonition, and may be accompanied by a rigor to be followed by fever; the pain over the region of the cæcum is exquisite; constipation exists sometimes so markedly as to suggest obstruction. To relax the abdominal muscles and keep them at rest, the patient will lie on the side with the thighs flexed; for the same reason the respiration is thoracic. Cutaneous sensibility over the inflamed area is much increased; pulse and temperature are both increased in ratio commensurate with the gravity of the other symptoms; vomiting is usually present and persistent, but does not partake of the characteristics known as fæcal.

A tumor is sometimes to be found at this stage, though not present at the onset of the attack; yet to this there are many exceptions; hiccough is also sometimes noticed. The evidences of grave disease increase; pulse and temperature rise, peritonitis is recognized, and fatal collapse closes the scene. So acute and rapidly fatal a seizure is exceptional, and suggests impaction in the appendix at a point where it is surrounded by peritoneum, with ulceration followed by fæcal extravasation into the general cavity of the peritoneum. Usually irregular bowel function precedes an attack; constipation alternates with diarrhœa, there is intermittent pain, and a tumefaction becomes apparent in the right iliac fossa; at first it is resonant on percussion, from being overlaid by small intestine, but later, as the swelling increases, it nears the anterior abdominal wall, and dulness on percussion is noted. The symptoms mentioned as incident to an acute attack may now appear gradually, or may be modified by extravasation of contents of the intestine into the connective-tissue outside of the peritoneum, giving rise of course to extensive suppuration, which will make its way in different directions, according to the anatomical peculiarities of the locality; or by extravasation of intestinal contents into a part of the peritoneal cavity which has been shut off from the main portion by adhesions; or, finally, by the escape of such contents into a neighboring organ, after the latter has first become adherent to the inflamed part. When the intestinal wall has given way, in one of the ways just mentioned, then there appears a series of phenomena not indicative of bowel inflammation, but pointing to connective-tissue suppuration, which is caused by, and is a complication of, the bowel lesion. The purulent collection, if small, may undergo absorption, become encysted, and remain quiescent; usually, however, it makes its way in the direction of least resistance, and may set up phlebitis, pyæmia, etc. Perityphlitic abscess has been known to open into the rectum, into the internal iliac artery, into the colon, or into the small intestine; it has also been known to make its way into the hip-joint, or into the thigh, to perforate the bones of the pelvis, etc. A pin, having perforated the appendix, penetrated the portal vein, and abscesses in the liver followed. Perforation of the appendix has been followed by perinephritic abscess, and by purulent pleurisy from perforation of the diaphragm (Andouard). Worms have escaped into the peritoneum through a perforated appendix (Becquerel). Packard records a communication of the appendix with the ileum through a mesenteric gland. This record of the directions in which perityphlitic and typhlitic pus has made its way could be greatly enlarged, but enough has been said to show the progress of the malady.

Perforation of the cæcum usually takes place toward the lower or posterior aspect; while in perforation of the appendix the ulceration is apt to be near its opening into the cæcum, or at the closed extremity. The orifice through the bowel wall is irregular, not clean cut, and may be so extensive as to separate the appendix from the cæcum. Jackson records a case in which, after recovery, the appendix was passed at stool, and in a number of cases a portion of the appendix has been found floating in the abscess or peritoneal fluid.

Acute suppurative inflammation of the lax connective-tissue overlying the iliac muscle is occasionally seen, and may occur without immediate implication of the cæcum;

if, however, the inflammatory process is allowed to go on unchecked, the bowel wall becomes implicated, and to all intents and purposes a perityphlitis is then established. In such a condition, the intestinal walls give way after the evacuation of the abscess, if an external exit be afforded; otherwise the pus may discharge into the bowel. The pus will be ill-smelling, in consequence of the immediate vicinity of the cæcum with its fæcal contents. Meteorism is less marked than when the inflammation commences in the bowel, and since the iliacus muscle is involved somewhat, the corresponding thigh is apt to be flexed slightly, and held motionless, or nearly so. There is perhaps one symptom which has not been referred to as liable to cause mistake, namely, diarrhœa. It must be remembered that there may be retention of solid fæces while liquid passages are taking place, the fluid passing around the solid portion; but what is still more important to remember is, that the cæcum projects as a blind pouch below the normal passage-way between the large and small bowel, so that the contents of the intestines need in nowise be obstructed while in transit, and yet the cæcum or appendix be tightly impacted.

In acute typhlitis, the symptoms usually point plainly to the *diagnosis*, and there is small chance of error; when, however, the affection is chronic, and when a collection of pus deep in the pelvis has added a new set of symptoms to those already in existence, then great difficulty may be experienced in arriving at an accurate opinion. Tumor of the kidney, simple impaction of fæces, cancer of the cæcum, psoas abscess, and abscess of the abdominal wall, are liable to be mistaken for typhlitis. It is to be also noted that a prolapsed pyloric cancer may be found in the right iliac fossa.

The *prognosis* is always grave, and if perforation have occurred the outlook is bad.

Should perforation not occur, a long convalescence must be expected, marked by tenderness at the seat of the disease and by irregular action of the bowels. Should perforation occur, if the patient escape an immediate fatal peritonitis, a long period of suppuration, with attendant septic dangers—for the pus-forming tract and bowel communicate—awaits the patient. Occasionally an acute pyæmia supervenes, as in the portal phlebitis already referred to, but usually, even though a quantity of fæcal pus be present, purulent absorption does not occur. If recovery ensue, inflammatory adhesions may greatly impair the integrity of the alimentary canal, or even bring about obstruction.

TREATMENT.—The proper treatment for a foreign body impacted in the appendix, about to cause ulceration and peritonitis by escape of bowel-contents, would be to cut into the belly, open the appendix, remove the impacted substance, sew up the wound in the intestine, and close the belly, with such precautions of cleanliness, etc., as are common at the present day. Unfortunately our methods of diagnosis do not enable us to make a sufficiently accurate diagnosis at an early stage, and the advent of peritonitis may be needed to justify an opinion. Would it be proper on the occurrence of perforation, as shown by collapse, etc., to do a laparotomy, cleanse the peritoneum, etc., and sew up the intestinal wound, or fix it in the abdominal incision? I believe that this would be proper, and that it is the treatment needed for the affection, but the difficulty of diagnosis causes hesitation. I trust that the time is not far distant, when we shall be able to recognize acute typhlitis resulting from impaction, and will then institute successful operative treatment. For this affection at present, our main reliance in treatment is in opium, pushed to the production of marked narcotism; while locally, a bladder of ice, if it can be borne, will be found beneficial. If the ice cause pain, an ointment of belladonna and mercury may be used. If inflammation is marked, and symptoms of suppuration appear coincidently with a tumor in the iliac fossa, exploration is very decidedly indicated; this is best done by puncturing the skin with a bistoury, and then passing a grooved or hypodermic needle into the tumefaction. Should pus be found, the needle is to be used as a director, and a free incision made. Fluctuation need not be waited for, since it is important that exit to the pus be given before extensive injury to surrounding parts occurs. Should a dépôt of pus not be found, the incision will have done no harm; for the suppuration which gives rise to the constitutional reaction will make its way toward it, and discharge the more easily. All cases of typhlitis or perityphlitis do not run an acute course, in the manner described above, and the modes of treatment may therefore be divided into those which are expedient before, during, and after the attack.

As the onset of typhlitis is often preceded by irregular bowels, etc., a light, digestible diet, and a large warm-water enema every other day, to be followed by saline laxatives, may restore healthy digestion, and the patient may regain health. When an attack has already set in, purgatives do harm by urging the inflamed or irritated intestine to action. Opium is indicated to allay pain and spasm, in doses sufficient to obtain the result sought for. Blood should be abstracted by leeches from the inflamed region, and the bites should be allowed to bleed. At the same time copious warm-water enemata should be given, so as to empty the large intestine and facilitate the passage of matter through the irritated area. The diet should be in small quantity, and of an easily digestible character. If the irritation or inflammation has existed any time, warm applications over the seat of pain give comfort. Ice by the mouth is very agreeable to the patient.

Should the disease not be severe, convalescence is to be expected in two or three weeks, and a mild laxative may be given with advantage, but only when recovery is assured; castor-oil is, I believe, the best purgative under the circumstances. Should inflammatory symptoms continue, ulceration and perforation of intestine, with extravasation of contents, may be looked for. The treatment proper for peritonitis from extravasation has been referred to, and should be adopted, if it can be put in practice, soon after the accident happens; if, however, diffuse general peritonitis is already well established, a fatal result will probably be hastened by laparotomy. If extravasation occur into the pelvic connective-tissue, it will be of course followed by suppuration, which will require evacuation by surgical means rather than that it should be allowed to burrow in the direction of least resistance at the cost of the patient's welfare. No special directions can here be given, for the case is no longer simply one of perityphlitis, but one presenting a grave surgical complication.

During a typhoid fever, ulceration may be present in the cæcum or appendix, and give rise to profuse hæmorrhage; in tuberculosis or dysentery, also, may ulceration occur, but it requires no special mention in this place.

The same may be said of cancer of the cæcum.

Strangulation of the intestine by the appendix is a rare but well-known accident; it is due usually to the free end of the appendix becoming adherent to some peritoneal surface, the middle portion remaining free. A loop of bowel, by passing beneath this free portion, may become strangulated. A long and freely movable appendix has become wrapped around a piece of intestine so as to close it. The ileum is more apt to be strangulated than any other division of the small intestine. Intussusception is noticed near or through the ileo-cæcal valve, with greater frequency than elsewhere in the abdominal cavity, and may suggest typhlitis. The differential diagnosis is usually easily made.

The cæcum or appendix, or both, may form a hernial protrusion, and so suffer strangulation; it is fair to suppose the existence of a long meso-colon under these circumstances. This accident is more frequent, I am inclined to think, in congenital hernia than in the acquired variety. *Louis McLane Tiffany.*

CÆSAREAN SECTION. The term Cæsarean section is applied to an operation which consists in opening the abdomen and uterus of the pregnant female, and by this means in making an exit for a living child, which could not possibly be born alive if delivered by the natural passages.

This operation was performed by the Greeks after the death of the mother. Among the Romans it was decreed

that no pregnant woman should be buried until the child had been delivered by the abdominal section, and the name of Cæsar was given to all children born in this way.

It was acknowledged by the Christian Church as being a justifiable operation, and was practised for the first time on the living woman, in 1500, by Jacques Nufu, who performed the operation with success on his own wife; but it was not until 1581 that the first treatise on the subject, by Rousset, appeared. At first no attempt was made to close the uterine wound, for all the attention seems to have been placed on the manner of closing that of the abdomen. Libas, in 1769 and 1771, was the first to close the uterus with sutures after the operation, but this proceeding was lost sight of until 1828 and 1852, when it was carried out, in this country, by Dr. Frank E. Polin, of Kentucky, who first used the silver-wire suture for the uterine wound.

The following statistics by Schroeder, in 1874, give the results of the operations up to that time:

	Cases.	Recoveries.	Deaths.
England	480	236	244
Germany	712	332	380
France	344	153	191
Belgium	11	4	7
Italy	46	5	41
America	12	8	4

The percentage of deaths is about fifty-four per cent., but some other authors make it as high as eighty-five per cent.

Dr. Robert P. Harris, of Philadelphia, gives some statistics of 120 cases of the Cæsarean operation in the United States, and one is struck with the results of the operations performed in the country compared with those performed in the cities.

	Cases.	Cures.	Per cent.
In the country	32	20	62½
In small towns	55	19	34
In large cities	33	11	33

Dr. Harris gives the following as the latest statistics of the Cæsarean operation: In the United States, 127 cases, 53 cures; in all North America, 135 cases, 60 cures: in England, 141 cases, 25 cures.

The Indications for the Operation.—The *absolute indication* for the operation is a deformed pelvis, so pronounced that the child neither dead nor alive can be delivered by the natural passages, or, indeed, be delivered without greater danger to the mother than that involved in the Cæsarean operation.

The Relative Indication.—When the pelvis is so narrow as not to allow of the passage of a child, of the ordinary dimensions, at term, even if the volume of the child has been previously reduced; that is to say, when one has the choice between cephalotripsy, embryotomy, or the operation of Cæsarean section; but authors are not agreed as to the amount of contraction of the pelvis which would indicate the operation.

Cazeau thinks the operation is indicated when the pelvic contraction measures five centimetres (two inches), and Tarnier is of the same opinion. Depaul prefers the Cæsarean section when the pelvic contraction is only six centimetres and the child is alive.

Scanzoni would even prefer the operation for a living child if the contraction was only eight centimetres.

Deformities of the pelvis may be due to rickets or to mollities ossium, and the pelvic outlet may be also contracted by tumors, pelvic hæmatocele, cellulitis, and a carcinomatous cervix. Moreover, the operation is indicated in cases in which the mother prefers the operation rather than to sacrifice the life of the child; also in cases of death of the mother while the child is viable.

Modifications of the Operation.—There are many modifications of the Cæsarean section, but mention will only be made of them, and they can be found under their various headings: 1, Porro's operation, "ovaro-hysterectomy;" 2, Thomas' operation, "laparo-elytrotomy;" 3, Porro-Müller operation; 4, symphyseotomy; 5, Sänger's operation, "sero-serous." The last of the modifications (Sänger's) is introduced to revive the old method of performing the Cæsarean operation, and will be spoken of later on.

The Conditions of the Operation.—There are three conditions to be fulfilled before one is warranted in performing the operation: 1. That the operation should be absolutely necessary; that is, that there is no other way to end the labor. 2. That the child should be living and viable. 3. That the mother should understand all the dangers of the operation and should consent formally to the operation.

The Time Most Favorable for the Operation.—Most authors are agreed that the most favorable time is that which just precedes, or immediately follows, the rupture of the membranes, for at this time the os is well dilated and the uterine contractions, which have already existed for some time, acquire a more regular and intense character. If one operates much earlier than this, the uterine contractions after the operation are apt to be insufficient, and if much later, the danger to the child is considerably increased.

Dr. Harris gives statistics as follows: 24 hours before labor, 7 operations, 7 cures; 34 hours before labor, 7 operations, 4 cures; 34 hours after labor, 10 operations, 1 cure.

Radfort gives statistics of 100 cases as follows: 24 hours before labor, 24 operations, 7 cures; 24 hours after labor, 76 operations, 9 cures.

Statistics in regard to the operation and its relation to the rupture of the membranes are interesting. Kayser gives the following:

Rupture of Membranes.	Mothers. Cases.	Mothers. Cured.	Children. Cases.	Children. Cured.
Before or six hours after	39	20	39	34
Seven to twenty-four hours after	35	24	32	25
More than twenty-four hours after	38	13	37	19

It is a curious fact that the Cæsarean section seems to lose something of its gravity when it is performed on women who have already undergone the operation. Lungren has collected all the cases of Cæsarean section performed at different times on the same woman, and gives the following result: On 48 women the operation had been performed 119 times; 8 mothers only have died and 40 have been saved.

Preliminary Precautions.—The precautions are the same as in the operation of ovariotomy. The operator and assistants should have their arms bare to the elbows. Soap, water, and nail-brush should be freely used, and the hands and arms should be well scrubbed. During the operation the hands of the operator should be washed frequently in a five per cent. solution of carbolic acid, or in a solution of the bichloride of mercury (1 to 2,000).

The operating-room should be particularly set apart for the purpose, and should be kept at a temperature of 68° to 70° F. The spray should be used several hours before the operation. The sponges should be new, and should be thoroughly cleaned with acids and hot water. During the operation they should be soaked in a solution of carbolic acid, 1 to 20.

The instruments should be kept in a carbolic solution during the operation, and counted both before and after the operation.

The operating-table should be hard and high, and should be open on all sides. The sponges which are to be used in the abdominal cavity should have a string and weight attached, as the weights hanging outside the abdomen will indicate the number of sponges inside, and will lessen the danger of leaving any sponges in the cavity after finishing the operation.

Assistants.—Four assistants, at least, are necessary; one to administer the ether and keep the patient fully under its influence; one to fix the uterus against the abdominal wound and to keep the intestines in the abdominal cavity; another assistant to take charge of the instruments and sponges, to pass them to the operator and to see that none are left in the abdominal cavity; and, lastly, a trained nurse to take the child after delivery and give it all necessary attention.

The instruments necessary for the operation are: a scalpel, a blunt-pointed bistoury, two pairs of scissors, a director, artery-forceps, pressure-forceps, sutures, needles,

needle-holder, new sponges, silver wire, the cautery, glass pressure-plates, and Wells' clamp.

The dressings consist of protective silk, antiseptic gauze, antiseptic absorbent-cotton, and a broad roller-bandage of unstarched muslin.

THE OPERATION.—This may be divided into four stages:

1. The incision through the abdominal wall. This should be done slowly and deliberately, care being taken to stop all hæmorrhage.

2. The incision in the uterine wall and the extraction of the child. This should be done quickly, as any delay in this stage may lead to formidable hæmorrhage.

3. The delivery of the placenta, arrest of hæmorrhage, and cleansing of the abdominal cavity.

4. The uniting of the wounds and the dressing and care of the patient.

There have been many situations recommended for the abdominal incision, but the one in the linea alba is generally used. Guy de Chauliac, 1363, and after him Roesslin, in 1513, advised that it should be made in the left side to avoid the liver. Rousset advised either the right or the left side, while Levret recommended that the incision should be made on the side toward which the uterus was lying at the time of the operation. The side incisions are rarely used, while the transverse and diagonal incisions have been abandoned.

FIG. 543.—Represents the Different Positions in which Cuts have been made in the Abdominal Wall.

First Stage of the Operation.—Clean and shave the abdomen and wash the parts with a solution of carbolic acid (1 to 20), or with a solution of bichloride of mercury (1 to 2,000).

After emptying the bladder, the uterus should be held immovable against the abdominal wall in order to press the coils of intestines as far from the middle line as possible. The first incision should be about six inches long, in the linea alba, extending from the umbilicus to within two inches of the symphysis pubis.

The incision should not be carried too far downward near the symphysis, as the bladder may be injured. If it becomes necessary to increase the size of the abdominal opening, the incision may be carried above the umbilicus, going to the left of it, in order to avoid the suspensory ligament of the liver, and also an abnormal anastomosis which sometimes exists between the hypogastric and umbilical veins.

All hæmorrhage must be stopped before the peritoneal cavity is opened. The first opening should be small, and the incision extended on the finger or director until a sufficient opening is made.

The second stage of the operation consists in opening the uterus and extracting the child. As the first stage should be performed slowly and deliberately, so should the second be done quickly and decisively. When the abdominal incision is made and the peritoneal cavity opened, the uterus, which has been kept well up against the abdominal wall, presents itself at the opening, while the intestines are pressed to either side and behind it.

The assistant should take particular care to keep the uterus pressed well into the abdominal wound, for in this way only can the intestines be kept in place. To prevent hæmorrhage, as far as possible, when the uterus is opened, pressure should be made around the cervix. The greater the hæmorrhage the more quickly the second stage of the operation must be performed. On moribund patients hæmorrhage in this stage need not be feared, as in numerous cases in which the operation has been performed in the interest of the child only, the hæmorrhage has been extremely slight, and the uterus contracted well after the child had been delivered.

If the membranes are intact they must be divided on a director or upon the finger as a guide. The uterine wound should be of the same length as the abdominal one, but should not be carried too near the fundus of the uterus, as wounds in that situation gape badly and do not cicatrize well.

As soon as the uterine incision is made and the membranes are ruptured, an assistant should place his index-finger in the upper angle of the uterine wound and hold the uterus up against the abdominal wall; and another assistant should do the same at the lower angle. By this means the uterus is held firmly in place, and the operator can remove the child by whichever extremity presents itself.

The child should be delivered slowly, care being taken that the uterine wound is not injured. Should the uterine wound be at the placental site, cut through the placenta and deliver the child as quickly as possible, and then remove the placenta and membranes.

As a general rule the feet present themselves and can easily be seized. As soon as the child is delivered tie and cut the cord immediately and give the child over to an experienced nurse, who will give it all necessary care. Whenever the head presents itself the child should be delivered by that extremity, and when the head is outside the abdominal cavity the rest of the body will follow very easily. During the whole stage of extraction an assistant should keep the uterus well contracted and up against the abdominal wound, to prevent any escape of blood or amniotic fluid into the peritoneal cavity. If the uterus is well pushed up against the abdominal wall it will also prevent the escape of any coils of the intestines.

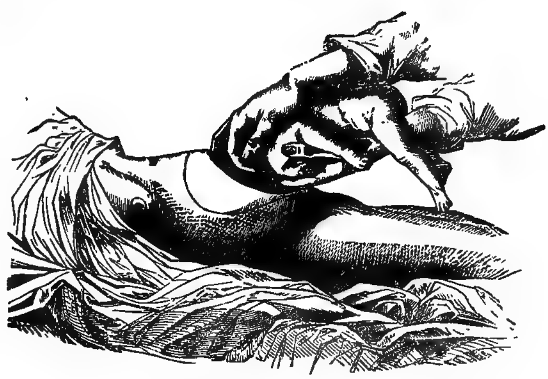


FIG. 544.—Second Stage of the Operation; Extraction of the Child.

The Third Stage.—The delivery of the after-birth and arrest of hæmorrhage. As soon as the child is born the operator should proceed at once to the delivery of the placenta and its membranes. This should be done slowly and carefully.

Generally after the birth of the child the uterus contracts well, and there is very little hæmorrhage. All clots of blood should be removed from the cavity of the uterus, and the organ itself should be stimulated to contract by friction, by the application of cold, or by the subcutaneous injection of ergotine.

℞. Ergotine .... gr. xv.
Glycerinæ .... ʒ j.
Aquæ destil .... ʒ jss.
M. Sig.—Dose, twenty to thirty minims.

The Fourth Stage.—The uniting of the uterine and abdominal wounds. When all hæmorrhage has been arrested and the peritoneal cavity thoroughly cleansed, the uterine and abdominal wounds must be closed as soon as possible by the use of the superficial and deep sutures.

The uterus must be well contracted and its cavity washed out with a solution of carbolic acid (1 to 20).

Drainage of the uterine cavity may take place through (*a*) the cervix and vagina; (*b*) the abdominal wound (utero-abdominal); (*c*) the abdominal wound, uterus, and vagina; (*d*) the Douglas' cul-de-sac and the posterior vaginal wall; (*e*) the bladder and anterior vaginal wall. The first of these routes is the best.

For the uterine wound, the silver-wire sutures, first used by Polin, of Kentucky, are preferred. They are to be placed as shown in Fig. 545: one, very deep and including all the uterine muscular tissue, brings the two surfaces of the wound in close and perfect apposition; the other suture is more superficial and only brings the edges of the wound together.

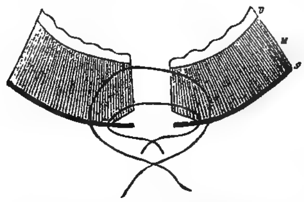


FIG. 545.—*D*, uterine mucous membrane; *M*, uterine muscular tissue; *S*, peritoneum.

For the abdominal wound the deep sutures are usually of silver, while the superficial ones are of silk or catgut; but some authors prefer the pin and figure-of-eight suture of Baudelocque.

There are three methods of uniting or closing the uterine wound: 1. Simply bringing the edges of the wound together with a superficial and deep suture, as in Fig. 545. 2. The utero-parietal suture, uniting the uterine and abdominal wounds. 3. The symperitoneal suture or the sero-serous method of Sänger (Figs. 546 and 547).

The last, or Sänger method, is a modification of the old method of performing the Cæsarean section, and consists in the different manner of uniting the edges of the uterine wound. He bases his claim for the operation on its analogy to operations on other viscera covered by the peritoneum, such as operations on the intestines, bladder, and non-pregnant uterus. The peritoneum is dissected up on each side of the uterine wound for a distance of one centimetre or more, and a thin segment of the uterine muscular tissue is cut away on each flap (see Fig. 546). The peritoneum, which has been dissected up, is then allowed to fall into the wound, when the peritoneal surfaces are brought together by deep and superficial sutures. These peritoneal surfaces unite quickly and prevent any fluids from escaping into the abdominal cavity. Three operations by this method have been reported, with success in each case, the mother and child both being saved.

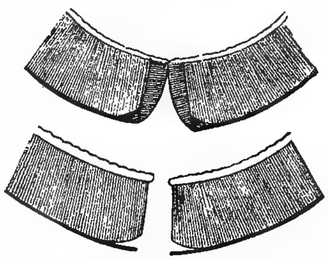


FIG. 546.—Represents the Second Step in Sänger's Operation; the Peritoneum and Uterine Muscular Tissue having been Dissected away.

The success of the operation depends largely, no doubt, on strict antiseptic precautions, cleansing the peritoneal cavity, and arresting all hæmorrhage before closing the abdominal wound. Drainage from the uterine cavity can take place through the cervix and vagina.

The complications to be expected in the last two stages of the operation are:

1. The uterine incision may be made at the placental site.
2. The arrest of the fœtal head by the lips of the uterine or abdominal wound.
3. Hæmorrhage.
4. The placenta may be adherent.
5. The protrusion of coils of intestines through the abdominal wound.
6. The escape of liquor amnii and of blood into the abdominal or peritoneal cavity.

It is sometimes possible to recognize the placental site before making the uterine incision, and then it becomes necessary to make the incision outside of the supposed area. (See article on Obstetric Palpation.)

1. If the placental site is not recognized before the uterine incision is made, the operation must be hurried; in case the incision is at the placental site, the opening must be enlarged and the placenta detached as soon as possible.

The child must be quickly removed and the uterus made to contract by some of the methods given above, in order to prevent an excessive loss of blood.

2. The head of the child may be arrested by the lips of the uterine or abdominal wound, in which case the incision should be enlarged at once unless the head can be delivered by simply enlarging the opening with the hand pressed between the edges of the wound and head. The life of the child is greatly endangered by this complication.

3. It is usually after the extraction of the head that the hæmorrhage is most severe; for while the child is in utero the uterine contractions are very regular, but as soon as the child is delivered the contractions of the uterus are less energetic, and the hæmorrhage may be quite severe. The only way to stop such a hæmorrhage is to increase uterine contractions, by cold, heat, or friction, and the subcutaneous injection of ergot. If these means are not sufficient, it is best to raise the uterus outside the abdominal cavity, in order to avoid the escape of blood into the peritoneal cavity. The uterus should not be replaced again until the hæmorrhage has entirely ceased.

Ritger advises, in order to guard against such a hæmorrhage, that the uterus should be always raised outside the abdominal cavity, and that the extraction of the child should not be made until the uterus has been thus raised outside.

4. Whenever the placenta is adherent, the adhesions must be quickly and carefully broken down and the placenta should be delivered through the abdominal wound and not per vaginam. Great care should be taken that no part of the placenta or membranes be left in the uterus.

The protrusion of the intestines may be prevented by pressing the uterus upward into the abdominal wound and by using large flat sponges on each side of the uterus in the abdominal cavity. All the sponges in use during the operation should be new, and should be counted both before and after the operation, in order to prevent the chance of leaving any of them in the abdomen. As already stated, strings and weights may be attached to those sponges which are to be used in the abdominal cavity, and these hanging outside will indicate the presence of the sponges inside, and will prevent any of them from being overlooked.

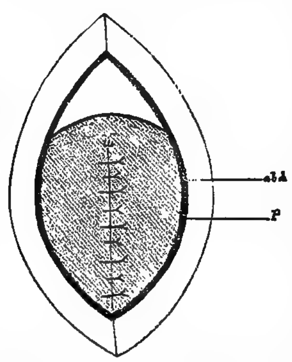


FIG. 547.—Shows the Appearance of the Uterine Wound; the Superficial and Deep Sutures being in place. *abd*, Abdominal wall; *p*, peritoneum.

Fig. 547 represents the appearance of the superficial and deep sutures of the uterine wound. After the uterus is returned to its place in the abdominal cavity, sponges should be placed in the abdominal wound to absorb any blood which may escape in closing the abdominal wound, and should remain there until the sutures are all in place.

The method of closing the abdominal wound is accomplished by the use of the deep silver wire and the superficial silk or catgut ligatures. The deep suture (Fig. 548) enters the abdominal wall an inch from the edge of the wound and passes entirely through, as shown in Fig. 545. A needle threaded with a double silk suture is first passed, and to the end of this is hooked the silver-wire suture.

By this means the peritoneal surfaces are brought together and all strain or pressure on the superficial sutures is removed.

The deep wire sutures are not twisted over the wound but are arranged as in Fig. 549.

The suture shown in Fig. 548 is the one now generally

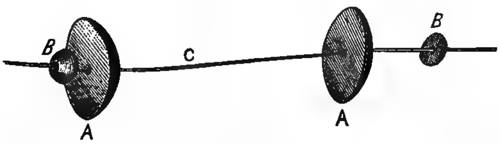


FIG. 548.—*C* represents the deep silver wire suture, with glass pressure-plates; *A*, *B*, buttons.

used. The glass pressure-plates and buttons, one on each side of the wound, are kept in place by twisting the end of the wire, when in place, about a small piece of wood. The plates and sutures bring the peritoneal surfaces together and take all pressure from the silk or catgut sutures. The deep sutures may be as numerous as the operator may think necessary. The superficial sutures simply bring the edges of the wound in close apposition. No drainage-tube is used in either the uterine or the abdominal wound, and any discharge from the uterus can easily escape per vaginam.

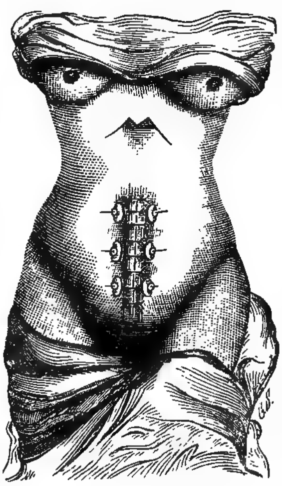


FIG. 549.—Showing the Appearance of the Abdominal Wound with Sutures and Pressure-plates in Place.

The Dressings.—A piece of gum protective is first placed over the wound, and over this a thick layer of antiseptic gauze, prepared with carbolic acid or bichloride of mercury. Over this is placed a larger wad of absorbent cotton, prepared in the usual way, and finally a firm bandage of unstarched gauze wrung out in a solution of carbolic acid (1 to 20).

THE AFTER-TREATMENT.—After the operation the patient should be moved carefully from the operating-table to the bed, which should be brought into the operating-room in order to avoid too much disturbance. Hot bottles should be placed at the patient's feet, and she should be covered with warm blankets and watched by a competent nurse or assistant until the effect of the ether has passed off.

If the wound unites by primary union the dressing need be removed only as there seems to be some urgent indication for so doing. At the end of four or five days the superficial sutures may be removed, and a few strips of adhesive plaster may be placed over the wound to hold the edges together. The deep sutures may remain in for eight or ten days, as the operator may think advisable.

The after-complications to be feared are nausea and vomiting, hæmorrhage, peritonitis, metritis, shock, septicæmia, and exhaustion.

In case of severe nausea and vomiting following the operation, the patient should be kept perfectly quiet, and ice or iced milk should be given frequently and in small quantities. Until the stomach becomes quiet, nutrition should be kept up by rectal injections of milk or partly digested food.

The bowels should be confined for the first few days after the operation.

The hæmorrhage, if there be any, may come from the abdominal wound, or from the uterine wound, or it may owe its origin to the circumstance that the incision was made at the placental site. The risk from hæmorrhage may be lessened by making the abdominal incision in the linea alba, by avoiding the placental site, by compressing the uterus firmly after the extraction of the child, and, finally, by the use of styptics and the actual cautery.

Peritonitis is usually due to a want of cleanliness, but also to the escape of liquor amnii, lochia, or other fluids, into the peritoneal cavity.

An unhealthy condition of the patient may predispose her to an attack of peritonitis. In the treatment of peritonitis the main reliance is placed on the internal administration of opium, and on the application of warm poultices to the abdomen. The opium may be given by the rectum in the form of suppositories, and by the subcutaneous injection of morphia.

Septicæmia is caused by the absorption of putrid matters into the blood, either from the peritoneal cavity or from the uterus.

When symptoms of this complication arise, *e.g.*, high fever, chill, etc., a few days after the operation, the uterus and vagina should be washed out with a solution of carbolic acid (five per cent.) or a solution of the bichloride of mercury (1 to 5,000), twice each day. Quinine in large doses may be given to lower the temperature, and stimulants should be given as indications arise for their use. Opium is rarely of use, and may do more harm than good.

Shock after the operation should be treated in the usual way, with heat, stimulants, etc.

The urine must be drawn twice daily, and particular care should be taken to wash the parts before passing the catheter, as in this way only can the discharges from the vagina be prevented from being carried up the urethra into the bladder. There should be nothing to prevent the free escape of lochia from the vagina, and the uterus may be washed out with the solution of carbolic acid as often as the patient's condition may seem to demand it.

On the fourth day after the operation the bowels may be moved by an enema. Recovery is, as a rule, slow, and it is rare for the patient to be up and about before five or six weeks, during all of which time she should be nursed with the greatest care, for to poor nursing may be attributed some of the bad results of those cases which have been reported. For several months after the operation the patient must wear an abdominal supporter.

THE PROGNOSIS.—Up to the present time statistics show that the mortality in cases of Cæsarean section is about eighty-five per cent., but in many of these cases the operation has been performed as a last resort, the patient being moribund at the time of the operation. Statistics also show the curious fact that operations repeated on the same woman are followed by better results than the primary operations. The great majority of deaths occur during the first three days after the operation.

Michaelis and Oetler have operated four times on the same patient. Barnes explains the good results in these cases by the fact that after the first operation the uterus, in cicatrizing, probably contracts adhesions with the abdominal wall, and if the patient again become pregnant, and the operation be again rendered necessary, this operation will be attended with less danger, because these adhesions close the peritoneal cavity, and the incision into the uterus through the abdominal wall will in that case come upon the part of the uterus which is adherent to it. Thus the danger from hæmorrhage and effusion into the peritoneal cavity is greatly diminished, and it is possible also that the shock of the operation is much less under such circumstances.

SUMMARY.—1. The nearer the linea alba the abdominal incision is made, the less will be the hæmorrhage.

2. The earlier the operation, the better the prognosis for mother and child.

3. Chloroform, by leading to uterine inertia and vomiting, is an unsafe anæsthetic. Local anæsthesia, if possible, would be better.

4. Ether is the safest anæsthetic.

5. Before the day of anæsthetics the Cæsarean section was a safer operation, as there were no secondary anæsthetic effects.

6. The operation is not very painful after the skin has been incised. Stitching the abdominal wound is painful.

7. To arrest uterine hæmorrhage and prevent its return, suture the uterine wound with wire and not with catgut or silk sutures.

8. Ice is useful for exciting uterine contractions; so also are vinegar and ergot, given internally.

9. Keep the peritoneal cavity as clean as possible, and remove all fluids in the cavity before closing the abdominal wound.

10. Drain the uterine cavity through the vagina.

11. To avoid post-partum uterine relaxation, operate early, before labor begins.

12. If the fœtus is dead, wash out the uterus, after delivery, with a solution of carbolic acid (five per cent.).

Charles Ware.

CAFFEINE (*Caffeina*, U. S. Ph.; *Caffeinum*, Ph. G.; *Caffeia*, *Theine*, *Guaranine*, etc.). The characteristic alkaloid of coffee and tea. It was discovered and first prepared, in an impure condition, from Coffee, by Runge, in 1820, and shortly after, in a state of greater purity, by Pelletier and Robiquet, and other chemists. In 1827 Oudry separated an alkaloid from Tea, which he named *theine*. This, in 1838, was proved by Mulder and C. Jobst to be the same as Runge's caffeine. In 1840 Martius discovered *guaranine* in Guarana, and afterward the same observer, and others, proved its identity with the alkaloid of Coffee. The same substance was also found, in 1843, by Stenhouse, in the leaves of Maté or Paraguay Tea, and in 1865, by D. Daniel and by J. Attfield, in the Cola Nuts (*Sterculia*) of Africa. In all these products it appears, moreover, to be the most important ingredient. As no two of these plants are nearly related to each other, or are even in the same order, caffeine may yet be found to be as widely distributed in the vegetable kingdom as berberine or buxine. It is an interesting fact that all the above substances have been used from a remote time by communities which could have had no communication with each other, for exactly the same purpose, viz., as a stimulating and comforting addition to their daily food: tea by the Chinese, coffee by the Arabs, the cola nuts by the Africans, and maté and guarana by different tribes of South America.

For commercial purposes caffeine is prepared exclusively from tea and coffee; the poorer sorts, that is "tea dust" and damaged and inferior grades of either tea or coffee, being used. As the price of both these articles does not depend at all upon their alkaloidal strength, but only upon their appearance and flavor, the cheaper grades often contain considerably more caffeine than the more expensive ones, and, price apart, are better for this purpose.

As caffeine is a weak base easily separated from its natural combinations, when it has any, and as it is pretty soluble in water and can be volatilized by heat, its separation from the crude products containing it is comparatively easy, and may be effected in several ways. Thus an infusion of coffee may be treated with magnesia, filtered and evaporated, and the resulting caffeine purified by recrystallization. Or alcohol or petroleum benzin may be used as the first solvents, with suitable modifications of the purifying and separating processes. Or an evaporated extract may be mixed with sand and the caffeine volatilized like camphor or benzoic acid. One of the best modern processes is that of Versmann, described as follows: Mix the powdered coffee with calcic hydrate, percolate with eighty per cent. alcohol, distil off the spirit, treat the residue with water, remove the fat, which separates on standing, and evaporate the liquid until it crystallizes upon cooling. Dry the caffeine so obtained between folds of filtering paper, dissolve it again in water, filter through animal charcoal and recrystallize (Husemann). The same method may be employed in separating it from tea and guarana.

The proportion of caffeine in these different substances varies considerably, and, as noticed above, does not depend, in the case of tea and coffee, upon their acknowledged quality. According to the researches of Stenhouse, coffee contains from ½ to 1 per cent., tea from 2 to 2.1 per cent., guarana 5.07 per cent., and Paraguay tea from 1.1 to 1.2 per cent. Cola nuts yield 2.13 per cent., according to Attfield. These figures are, however, subject to considerable variations, for coffee may contain two or three per cent., and tea and the others may have less than one per cent. Although guarana yields the greatest amount, its high price excludes it from competition with teas and coffees as a source of caffeine.* The other articles are only to be had here as curiosities. Caffeine has also been obtained from coffee *leaves*, which are used; to a slight extent, as a substitute for coffee and tea. Roasting the coffee dissipates a small portion of the caffeine, but does not alter that which remains. Finally, it has been prepared by synthesis with theobromide of silver and methyl iodide (Stricker).

Commercial caffeine is in beautiful, long, flexible, silky crystals, resembling finely spun glass in whiteness and lustre. It is permanent in the air, and dissolves, according to the U. S. Pharmacopœia, in seventy-five parts of water and thirty-five of alcohol, at 15° C. In absolute alcohol and in ether it is less soluble. The combining power of caffeine is very feeble, and although it forms salts with several acids, it retires from the combination in dilute solutions, and sets the acid free. Its taste is moderately bitter.

ACTION AND USE.—Poisonous doses of caffeine administered to frogs occasion convulsions, followed by rigidity of the muscular tissue; administered to birds and mammals, restlessness, rapid breathing, tonic and clonic convulsions, and, finally, death by asphyxia. It also disturbs the heart, at first increasing and afterward diminishing its frequency and force. The temperature, in an early stage, is raised, afterward reduced. The effects of correspondingly large doses upon men have not been observed, as no case of fatal or dangerous acute caffeine-poisoning has been recorded. In smaller doses, its principal effect is exerted upon the intellectual centres, in increased mental activity, as shown by the vivacity and ease of thought and expression which follows its administration. In medium and large medicinal doses wakefulness and restlessness are commonly observed, occasionally trembling of the limbs, dizziness, intense nervousness, distressing vigilance, and palpitation. Hiccough, vomiting, headache, and confusion of thought have followed ordinary doses given to peculiarly susceptible patients. It has been claimed for caffeine that it reduces the waste of the nitrogenous elements of the body, but while this is in some degree probable, it cannot be considered as proved. It sometimes increases the quantity of urine, and usually excites the heart to increased action.

The most frequent use of caffeine is to alleviate hemicrania and other nervous headaches, for which it is sometimes a delightful specific; fully as often it fails entirely, and in our present state of knowledge it is not possible to say in what particular cases it will succeed. In sick headaches it rarely gives complete relief, but is frequently of marked benefit, especially in hastening its departure after the climax is passed. It is probably only in cases in which the brain is debilitated or anæmic that any benefit can be expected from this medicine. Its employment as a cardiac stimulant in organic disease of that organ, and as a diuretic, is much less general, and probably much less useful.

The habitual use of coffee and tea by the majority of mankind destroys most of the medicinal value of caffeine, as toleration of it is rather easily accomplished. It is a generally accepted antidote for opium-poisoning, and while too inefficient to go far toward annulling the effects of that energetic drug, so far as its action extends it is in the right direction. For the after-headache, vomiting, nausea, and other ill-effects of opium or morphine, we have nothing better than the caffeine-containing beverages.

ADMINISTRATION.—The alkaloid itself is easily dispensed in powders or pills, and easily taken in water or in milk, or, if preferred, dry upon the tongue. Its bitterness is not of an intense or very disagreeable kind. It is

* A caffeine from Guarana is prepared by E. Merck under the name "Guaranin."

frequently united with tonics and other bitters, but is better given alone, as it is more useful in emergencies than for regular administration. Its union with other stimulants is often desirable. An extemporaneous solution in aërated water is a good one. If we could have a fluid extract of coffee, with a constant per cent. of caffeine, it would be better than any other form.

DOSE.—One decigram (0.1 Gm. = gr. jss.) does not generally produce much effect; from two to three ought to cause a little physiological disturbance and may be taken as medium doses; five or six decigrams should not be exceeded without some special purpose, as disagreeable excitement or vigil may follow. The citrate has no advantage over caffeine itself.

ALLIED DRUGS.—The caffeine-yielding substances above mentioned, Theobroma (see CACAO, BUTTER OF), and Coca are the most important. *W. P. Bolles.*

CAISSON DISEASE. In laying the foundations of bridge piers or abutments under water, various means are resorted to for displacing the water and building a solid basis; one of these methods is by means of caissons. The caisson is made of different patterns, but the one with which we have to do in the study of caisson disease is like a large inverted box, supplied with apparatus for condensing air to such a degree as to expel and keep out the water, thus enabling men to work in it. The workmen and material used are passed through a small space or anteroom called the "air-lock." When the men have entered this air-lock the outer door is closed and compressed air is gradually admitted until the air in the lock is of the same density as that in the caisson, then the door of admission to the latter is opened. In returning, the process is reversed, the air in the lock being gradually rarefied.

If the fact be borne in mind that the surface of the body has about sixteen square feet, and that ordinary atmospheric pressure is about fifteen pounds to the square inch of surface, it may readily be understood that an increase of atmospheric pressure will have some effect on the conditions of the interior of the body. The blood is driven, by reason of this external pressure, from the surface into the bones, cranium, spinal canal, and other parts of the body. If this change of location of the blood be effected too rapidly, or too much force be applied, the results may be dangerous.

In an essay on "The Effects of High Atmospheric Pressure, including the Caisson Disease," Dr. Andrew H. Smith, of New York, describes the symptoms induced by entering highly compressed air. These are: 1, Ringing in the ears and impairment of hearing; 2, increased frequency of respiration; 3, increase in the pulse-rate to 120, with subsequent fall to the normal; the pulse is reduced in volume and there is pallor of the skin; 4, the temperature of the body, an hour and a half after entering the caisson, is elevated about one degree, but when the atmosphere within the caisson is warmer than the external air, the body heat may rise as high as 101° F.; 5, the skin is covered with perspiration, but this is because of the saturation of the surrounding atmosphere, and not from any increase in the amount of the secretion; 6, increase of appetite; 7, increase of urine of about normal specific gravity (probably because of diminished evaporation from the skin).

The pathological effects mentioned are: 1, Rupture of the drum membrane and inflammation of the middle ear; 2, neuralgic pains, which may come gradually or suddenly, in the extremities or in any part of the body; 3, epigastric pain and vomiting; 4, paralysis, both sensory and motor, most frequently of the lower limbs, but, notwithstanding the paralysis of sensation, the pains continue; 5, the cerebral symptoms are: headache, dizziness, double vision, incoherence of speech, and sometimes unconsciousness. These symptoms are usually temporary. "Death occurs only in cases which are severe from the first, and are marked by symptoms of serous or sanguineous effusion about the brain or cord." "The constant lesion in fatal cases of caisson disease is congestion of the brain or spinal cord." "It is the *removal* of the pressure, and not the pressure itself, that is the immediate cause of the seizure," which occurs usually at the time when the victims are coming from under the pressure, or even some hours subsequently. The blood is driven by the atmospheric pressure from the surface into the bones and bony spaces, skull, and spinal canal, the vessels of which parts become dilated, and when the external pressure is removed they do not readily contract to their normal size. The remedy that Dr. A. H. Smith proposes for this condition is ergot, with morphine as required to relieve pain. *Charles E. Hackley.*

CAJEPUT, OIL OF (*Oleum Cajuputi*, U. S. Ph., Br. Ph.; *Oleum Cajeputi*, Ph. G.; *Cajeputi*, Codex Med.). The essential oil of the leaves of *Melaleuca Leucadendron* L. var. (*M. minor* Smith, *M. Cajuputi* Rox, etc.); Order, *Myrtaceæ*. This variety is a rather small, fragrant tree, with irregularly growing slender branches, and a thick, soft, exfoliating bark. This latter is dark on the trunk and limbs and white on the branches. The name of the

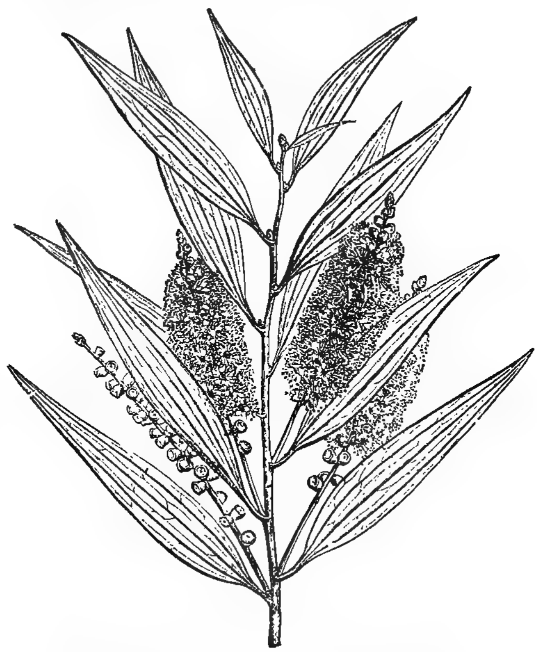


FIG. 550.—Cajeput Tree; Flowering Branch. (Baillon.)

plant is said to be derived from this circumstance (μέλας, black; λευκός, white). The leaves are bright, smooth, narrow, entire, pointed at each end, parallel nerved, and often oblique or curved; they are twisted upon their petioles so as to stand with vertical surfaces like phyllodia. The flowers are small, arranged in spikes or heads, with leaf-buds at the apices, which afterward develop into branches; calyx and corolla, inconspicuous pentamerous; stamens, numerous; filaments, long, united into five bundles at the base; ovary, three-celled. Fruit, a dry, hard, dehiscent capsule, persisting for several years upon the stem. The tree is a native of numerous islands in the Indian Archipelago, especially of Bouro, Celebes, and Amboyna. It is also extensively found, if a broad view is taken of the genus, in Australia and on the mainland of Asia. Most of the oil is obtained from Celebes, and exported by way of Javan or Indian ports.

Oil of Cajeput is extracted on the spot from the fresh leaves, which are first softened by maceration in water, and then subjected to distillation in rude copper stills. It is filled into once-used wine and beer or other European bottles for exportation. It was first introduced into Europe in the early part of the eighteenth century.

It is a pale-green, transparent, mobile fluid, with a fragrant mint or camphor-like odor, and bitterish aromatic taste. It has the usual physical properties of the essen-

tial oils, and consists chiefly of the hydrate of a terpene, called *Cajuputene*. Specific gravity of the oil, 0.926. The green tint is generally ascribed to some compound of copper received from the still, or introduced into the oil intentionally. On the other hand, there is good reason for believing that *Melaleuca* oil when freshly distilled is naturally green, irrespective of the presence of copper, from chlorophyl or some other vegetable color contained in it. Commercial oil of cajeput generally contains copper. The color may be separated by several methods of rectification, and the oil obtained clear and white.

Action and Use.—Cajeput has the stimulating properties of camphor and the essential oils in general, and stands between the most irritant of them, like oil of turpentine, and the milder mint oils. It is more extensively used in the Indies and Eastern islands than here—in some places being given for nearly everything, but is particularly popular for colics, diarrhœas, and even cholera, as well as for chronic rheumatism, chronic vesical catarrh, etc. Here it is not often given internally, but has no doubt some value in non-inflammatory intestinal disturbances, where an aromatic stimulant and antispasmodic is needed, being in these cases very much like camphor, and like this may be very suitably combined with opium. Externally it is a mild rubefacient, and a good ingredient for stimulating liniments in chronic rheumatism, old sprains, etc.; it may be also useful for psoriasis, scaly eczema, etc., and is a fairly efficient parasiticide. As a stimulant diuretic in chronic vesical catarrh it is as good as most others of its class. Cajeput is the basis of numerous toothache and earache drops. It is often adulterated. Dose, from one to five decigrams (0.1 to 0.5 Gm. = ♏ ij. ad viij.) dissolved in spirit, suspended in mucilage or syrup, or on a lump of sugar. There are twenty or thirty drops to the gram.

Allied Plants.—*Melaleuca* is a large, almost exclusively Australian genus, excepting the present species, which in many varied forms grows very extensively in the Pacific islands and in tropical Asia. Several of these varieties probably contribute to the supply of oil. For the order *Myrtaceæ*, see Cloves.

Allied Drugs.—The oils of the numerous species of *Eucalyptus* are almost exact medicinal substitutes. (See also Camphor.)

W. P. Bolles.

CALABAR BEAN (*Physostigma*, U. S. Ph.; *Physostigmatis Faba*, Br. Ph.; *Fève du Calabar*, Codex Med.; Ordeal Bean, etc.). The seed of *Physostigma veneneosum* Balf; Order, *Leguminosæ, Papilioneæ*. This is a large, climbing, perennial vine, with the general appearance of an enormous bean-vine. The stem is woody below and often as large as the wrist, and twelve or fifteen metres in length (thirty-five to fifty feet). The leaves are large, alternate, and, like those of the bean, trifoliate; leaflets ovate-acuminate. Flowers in loose hanging racemes, nearly as large as those of the sweet pea, showy. Calyx short and broad, with very short lobes. Corolla papilionaceous, but curved backward almost into a ring, the standard nearly enclosing the wings and keel. Stamens ten (nine and one as usual in the tribe). Ovary slightly stalked, one-celled, with several ovules, and surmounted by a long, remarkably curved spiral style, which makes about one and a half circle, and is thickened, hairy, and at last abruptly reflexed at its apex. The ripened pod is spindle-shaped, from four to seven inches long, and contains two or three very large seeds. The "beans" are very hard, oblong, slightly curved or kidney-shaped, from two to three centimetres in length, and about one and a half broad (three-fourths to one and one-fourth inch by one-half inch), and covered with a rough but shining chocolate-brown or brownish-red testa. A broad, shallow, black groove or furrow extends along the convex border and around one end of the seed: it contains the raphe. The kernel is exalbuminous and consists mostly of the two large, white, brittle cotyledons, whose faces are concave and enclose an air-space which enables the entire seeds to float upon, although when broken the fragments are denser than water. The taste and odor of the seeds are simply bean-like, and give no suggestion of the deadly poison which they contain.

Fig. 551.—Calabar Bean Vine; Flowering Branch, reduced. (Baillon.)

Fig. 552.—Calabar Bean, two-fifths natural size.

The plant grows about the mouths of the Old Calabar and Niger rivers in tropical West Africa, and is not very abundant, being, as is said, destroyed everywhere but where it is preserved for judicial purposes by the local governments. It has been transplanted to India, Brazil, and other places, where it flourishes. Physostigma is an ingredient of the poisonous mixture which persons accused of witchcraft or crime are compelled by the savage chiefs of these African tribes to take as an ordeal or punishment. The draught is usually rapidly fatal, unless vomiting occurs. It was first known in England about 1840 as a curiosity and poison, but not much employed in medicine until Fraser, of Edinburgh, about 1863, discovered its specific power of contracting the pupil, since when it has been in rather frequent use by oculists and in occasional use in internal medicine. Besides forty-eight per cent. of starch and about twenty of albuminoid matters, with a little oil and gum (substances which are contained as well in the common bean, and which are entirely inert), the drug in question has two peculiar and poisonous alkaloids. *Physostigmine* was prepared in 1863 by Jobst and Hesse as an amorphous, alkaline, not very permanent mass. In 1865 Vee and Leven obtained a crystalline alkaloid which they named *eserine*. It is easily soluble in ether, alcohol, or chloroform, but only sparingly so in water. In dry crystals or salts it is permanent, but its aqueous solution reddens upon standing and exposure. Eserine is now an article of commerce, and is furnished indiscriminately under the names "eserine" and "physostigmine." It is probably a pure form of Jobst's physostigmine. *Calabarine* is the second alkaloid; it differs from physostigmine in being insoluble in ether, and in its action, which is said to be like that of strychnine; it is not used.

Physosterin is a fatty or cholesterin-like substance, occurring in the calabar bean in common with other leguminous seeds; it is inert.

Action.—Vomiting sometimes occurs after taking either the crude drug or its alkaloids, and protects the victim from the effects of their absorption. When this does not take place the symptoms are, general and rapidly increasing motor paralysis, which progresses until the animal or person is unable to lift or stir a limb, and finally dies of asphyxia from paralysis of the muscles of respiration. The pupils contract, reflex motion diminishes and disappears, but muscular tremors are present even after voluntary motion is suspended. Sensibility and consciousness remain as long as they can be evinced, perhaps to the very end. The action of the poison is rapid; if the dose is large, death may take place in a few minutes, if smaller, after one or two hours.

The action of physostigma (meaning by this that of physostigmine, its principal alkaloid) is chiefly directed to the motor centres of the spinal cord, whose functions it rapidly diminishes or finally obliterates. Upon the

sensory centres and upon the nerve-trunks it has but little effect, while the muscles are made more sensitive by it. The heart does not appear to be appreciably affected. The intestines are excited to violent peristaltic movement, and often to diarrhœa; the pupils are strongly contracted.

Although possessed of such marked and definite properties, physostigma has not found a very extensive field of usefulness in medicine. Its local effect upon the eye, above alluded to, is frequently of use to oculists for contracting the pupil after atropine dilatation, and for certain other conditions; for this purpose it is always given locally, that is, a few drops of a one per cent. solution of physostigmine, or little tablets prepared especially for the purpose, are introduced into the conjunctival cavity. It has been, as may be easily imagined, looked to with great hopefulness as a cure for tetanus, the symptoms of which it would appear to logically antagonize, and it is more often given internally for this disease than for any other purpose, with some apparent success; but on the whole with so little as to show that the cause of this dread disease has not been reached by the remedy. In the same way it has been used as an antidote to strychnine poisoning with some, but not marked, benefit. The antagonism between calabar bean and belladonna has been very thoroughly demonstrated, and leaves little doubt that each is useful, to some extent, in combating poisoning by the other.

Administration.—In tetanus the object is to relax the contracted muscles, and the medicine must be given until its physiological effects are distinctly manifested, or no benefit is obtained. There is, no doubt, some danger in using it in this way, but the fatality of the disease is so great that a considerable risk is justifiable in the treatment if there is reasonable hope of benefit.

If given for strychnine poisoning, the same proposition would hold true. In atropine poisoning only moderate medicinal doses are worth while. The value of physostigmine in either of these cases is not wholly established. For chorea, atonic constipation, etc., the ordinary doses should not be exceeded. The dose of the powdered seed, which is not often given, may be taken, for a basis of computation, as from five to fifteen centigrams (0.05 to 0.15 gm. = gr. j. ad iij.); this makes that of the tincture (*tinctura physostigmatis*, U. S. Ph., $\frac{1}{10}$) from half to one and a half gram (0.5 to 1.5 gm. = ♏ viij. ad xv.), and that of the extract (*extractum physostigmatis*) from five to ten milligrams (0.005 to 0.01 gr., $\frac{1}{12}$ ad $\frac{1}{6}$). But the presence of calabarine in undetermined quantity in these preparations is a serious objection, and it should either be eliminated from them, or the alkaloid, physostigmine (eserine), be preferred in its stead. One of its salts, the salicylate (*physostigminæ salicylas*, U. S. Ph.), is permanent and reliable, and in general preferable when the exact effects of the remedy are desired: from a half to one milligram (0.0005 to 0.001) may be taken as an initiative dose, to be watchfully increased.

Allied Plants.—A variety of calabar bean, consisting of longer and straighter, but otherwise exactly similar seeds, has occasionally appeared, and is attributed to a different species of *physostigma*, provisionally named *P. cylindrospernum*. There are no other species in the genus, and the nearest genera, such as the beans, have no such poisonous qualities. For the order Leguminosæ, see Senna.

Allied Drugs.—Physostigma appears to stand apart from other medicines in its action. (See Curare.)

W. P. Bolles.

CALCIFICATION. Synonyms: Calcareous Infiltration, Calcareous Degeneration, Cretefaction, Petrifaction; Ger., *Verkalkung;* Fr., *Calcification.*

Definition.—Calcification consists in the abnormal deposit of earthy matter in or around the elements of a tissue, or in the morbid product of a pre-existing inflammatory process.

A calcareous infiltration of a cartilaginous or fibrous framework is the first step in the formation of bone. This is a physiological transformation, and is better known by the term ossification. Calcification and ossification were formerly looked upon as different stages of the same process, but they are by no means identical. Ossification is an active development in which the tissues are abundantly supplied with blood. There is a rapid cell-proliferation, and the calcareous matter forms an intimate and permanent union with the tissues. Calcification, on the other hand, is passive, and indicates an impaired vitality. In it there is no proliferation of elements, and the calcareous particles are simply deposited in the tissues, or encrust them, causing but little alteration of their structure, and without entering into an organic union with them. This is more commonly termed calcareous degeneration, although the degeneration of the affected organ is a result of the process rather than a part of it. Calcification begins, as a rule, in the interstitial tissue, only ultimately invading the cellular elements; ossification affects the cells either primarily or at an early period. Further, the product of a calcification usually resembles shell rather than bone, the calcium carbonate largely predominating; but other earthy constituents of bone, namely, the phosphates of lime and magnesium, are also present in varying quantity.

In regard to the origin of the calcareous salts, it is generally believed that they come more or less immediately from the blood, although Rokitansky supposed that they were formed by a metamorphosis of the tissues involved.

Causes.—The causes of calcification are of two kinds, general and local. The former relate to changes in the blood or its circulation; such, for example, as are the result of age or disease. In composition the blood may be so altered as to contain an abnormal amount of calcareous matter, an effect that is produced most commonly by the absorption of lime-salts from osseous tissues that are the seat of extensive caries, osseous cancer, sarcoma, or osteomalacia. The calcareous matter thus taken up is conveyed to other and often remote parts and there deposited, constituting the "metastatic calcification" of Virchow. Such metastasis is favored by any disease of the kidneys which hinders the elimination of the supra-abundant calcareous matter by that channel. When due to this cause, the infiltration usually invades a large number of organs. It is most common in the smaller arteries, particularly in those of the meninges, the pyramidal portion of the kidneys, the lungs, the mucous membrane of the alimentary canal, and the liver. The case reported by Küttner, of St. Petersburg, has become a well-known example of this. He observed a rapid calcification of nearly all the smaller arteries as a result of caries involving the dorsal and lumbar vertebræ in a youth of nineteen. Virchow has reported a similar case, in which, as a result of cancer affecting nearly all the larger bones, particularly the bodies of the vertebræ and the skull, the calix and pelvis of the kidneys, the parenchyma of the lungs, and the mucous membrane of the stomach were calcified.

The circulation of the blood may be retarded, and thus favor the precipitation of the calcareous matter which it normally holds in solution. To this change is chiefly due the frequency of calcareous degeneration in the aged, whose circulation participates in the general loss of vitality. Examples of this are found in the calcification of the laryngeal and costal cartilages.

Calcification rarely, if ever, depends solely upon general causes. There is always a local influence. Very often it is due to a pre-existing chronic inflammation. Old accumulations of pus, thrombi, extravasations, and exudations are exceedingly prone to calcification. To this category belong caseous lymphatic glands, and caseous nodules in the lungs. The deposit frequently occurs also in the fibrous wall surrounding these accumulations, and may occur in the fibrous septa of lymphatic glands (see Fig. 556). A mere loss of function predisposes to calcification, hence its occurrence in the thymus gland. Zenker attributes its occurrence in the lung to the inhalation of foreign matter.

The calcareous infiltration is frequently associated with fatty degeneration, and is so often secondary to it that by many the presence of fatty matter is considered essential to the occurrence of calcification. It is sometimes also associated with the pigmentary metamorphosis, and rarely with the colloid. Syphilis is recognized as a potent element in the production of calcification, owing to the

frequency with which it produces degenerative changes favorable to the infiltration of lime-salts.

With regard to the immediate nature of the process involved in the precipitation of the lime-salts, there is some difference of opinion. The simplest mode of explanation, and one which at present may be considered as correct as any we have, is to look upon the process as similar to that involved in the formation of stalactites. A certain amount of calcareous matter is a normal constituent of the blood, in which it is held in solution by the carbonic acid, always present in sufficient quantity to keep in solution twice the normal amount of earthy matter. When the circulation is impeded, the free carbonic acid, because of its great diffusibility, is readily absorbed by the tissues or goes to form new compounds, necessitating a precipitation of the calcareous matter. On the other hand, it has been suggested that these salts, having been conveyed to the part by the blood and there confined on account of the impediment to the circulation, form insoluble compounds with the non-volatile fatty acids, or soluble compounds with the volatile fatty acids, and thus become stored away in the tissues in considerable quantity, to be precipitated whenever, from any cause, the acid radicle is removed, the product in either case being converted by a process of oxidation into calcium carbonate. Litten claims that an affinity for calcareous salts similar to that of the fatty acids, is possessed by a retrograde metamorphosis of albumen.

Calcareous matter may be deposited in either a fibrous or a fluid matrix, but shows a preference for newly

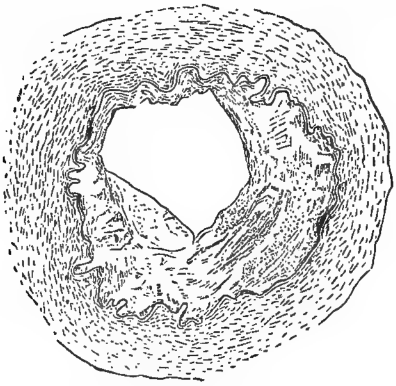


Fig. 553.—Artery showing Endarteritis Obliterans Syphilitica. (Drawing from a specimen of Dr. Wardwell; magnified about 700 diameters.)

formed fibrous tissue, particularly where this is associated with old tissue undergoing fatty degeneration and absorption. In a fibrous matrix the infiltration usually begins in the intercellular substance, but may invade the cellular elements at a later period. In a fluid matrix, as pus, the granules are frequently deposited primarily within the cells. The process may advance slowly or rapidly, and may vary from the slightest granular deposit to complete petrifaction. It may be confined to a single focus, or may be more or less disseminated throughout the body. When due to local causes it is more limited in the area of its invasion, than when there is also some general factor in its production, as in the metastatic form. It is likely to occur in all organs and tissues of the body, but not with the same frequency in all. One of its favorite seats of expression is in the coats of arteries affected by the atheromatous process (arteritis deformans), where it may invade the neoplastic tissue or be associated with a fatty degeneration of the atheromatous product, and is especially likely to accompany an abnormal dilatation of the vessel-walls (see Figs. 553, 554, and 555, copied from original drawings kindly furnished by Dr. William L. Wardwell, of New York). Cohnheim asserts that the constant change of the calibre of the vessels, impaired by age, is also a leading factor in the etiology of the infiltration.

The valves of the heart are frequently calcified as a result of endocarditis. The walls of the aorta, just above the semilunar valves, are among the most frequent locations; next come the arteries of medium and smaller size; the capillaries are rarely affected. Calcification of the veins is not common, and occurs usually as a result of varicose dilatation, giving rise to plates or the nodules known as phleboliths. Küttner suggests that the comparative immunity of the veins from this degeneration is due to the relatively larger amount of carbonic acid contained in venous blood, rendering precipitation less likely to occur.

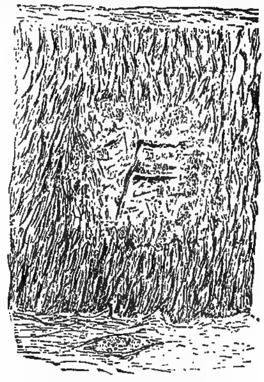


Fig. 554.—Calcification of Middle Coat of the Radial Artery. (Magnified about 700 diameters; Wardwell.)

Inflammatory conditions of the serous membranes, the arachnoid, pleura, pericardium, omentum, and synovia of the articulations, are followed by the production of calcareous plaques; and if the inflammatory action have involved the neighboring viscera, the infiltration may invade them. Various portions of the brain, especially the cortical ganglion cells, the spinal cord, nerve-trunks and ganglia, the meninges and nerve-sheaths may be infiltrated; the pineal body and the choroid plexuses are frequently involved. Calcification of muscles and their tendons is infrequent; ossification is much more common. It occurs, however, as a result of chronic inflammation or in the vicinity of a chronic arthritis; calcareous plates have been found in the muscular substance of the heart, in both muscular and tendinous portions of the diaphragm, as well as in the different skeletal muscles. The calcified remains of purulent accumulations, tubercles, and parasites are often found embedded in the substance of muscles. Other examples of the process are seen in the membrana tympani, in the crystalline lens and the several coats of the eye, in the fibrous capsule formed around foreign bodies or substances acting as such; around old fractures; in the remains of an extra-uterine pregnancy of long standing (lithopædia); in the skin and mucous membranes, and in all pathological new-formations, whether malignant or non-malignant. Chief among these are fibroid tumors. A fibroid of the uterus may become completely petrified; such "uterine stones" have been known since the time of Hippocrates. Finally, many concretions, as those occurring in the tonsils, the acinous glands of the pharynx, the salivary glands and the pancreas; the follicular crypts of the intestine; the prostate; and the otoliths found in the ear contain large proportions of lime and are formed by a precipitation of calcareous salts from the fluids in which they are found. Wedl attributed the formation of the bodies known as floating cartilages to the calcification of papillary growths in the joint. Not infrequently we find the salts of lime combined with other salts, as with the urate of soda in rheumatic arthritis.

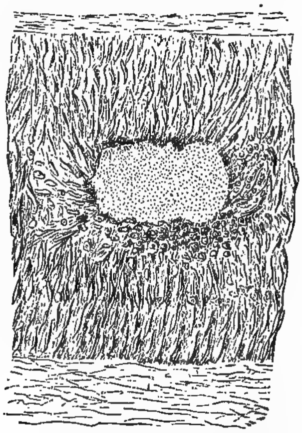


Fig. 555.—A Spot Analogous to the Preceding, from which the Lime salts have been Removed, showing Tissue remaining which has undergone a Coagulation-necrosis. (Magnified about 700 diameters; Wardwell.)

Physical Characteristics. — Partial calcification causes but little change in form or size of the affected organ or tissue, for the calcareous particles occupy only the space belonging to the fluids of the tissue; but when more advanced it may cause very marked deformity. It also renders the part firmer to a degree corresponding to the extent of the calcification. When incised, a calcified tissue imparts a gritty sensation, or may be so hard as to completely obstruct the passage of the knife. If in sufficient quantity, the calcareous matter may be recognized macroscopically as whitish, opaque masses, with sometimes a lustrous appearance. If one of these masses be immersed in a diluted mineral acid, the calcareous matter is dissolved with the production of bubbles of carbonic acid, leaving the original tissue in an almost normal condition. The effervescence thus produced depends upon the decomposition of the calcium carbonate, and the quantity of this ingredient may be estimated by the extent of the effervescence.

For microscopic examination, a thin section should be made and stained in carmine, which does not affect the calcareous matter. If the infiltration be not far advanced, the calcareous particles appear as minute, opaque, granules, like a sprinkling of dust. A little later many of these particles may be observed to have coalesced to form molecules of varying size and shape, presenting by transmitted light a dark outline with a bright centre, and by reflected light appearing as glistening spherules, occasionally exhibiting concentric rings Much more rarely crystals of calcium carbonate appear. When completely petrified, the highest type of calcification, the mass resembles aragonite. It is translucent, semitransparent, and more or less homogeneous, with here and there indistinct outlines of the original structure. The calcareous particles are visible chiefly along the borders of the plate, where the infiltration is more recent. Such a mass may be ground and polished after the fashion of preparing a specimen of bone for microscopic examination.

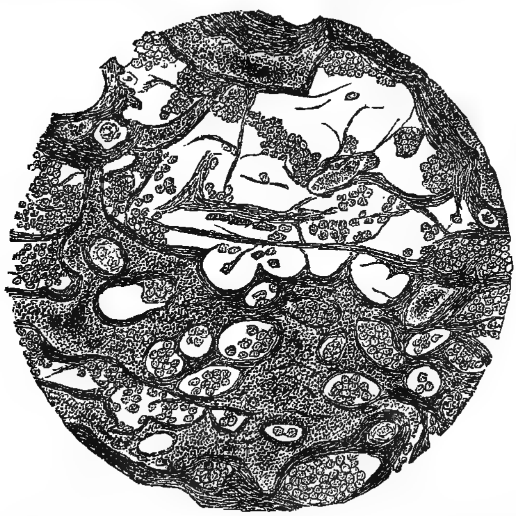


Fig. 556.—Section of an Inguinal Lymphatic Gland, showing Calcification of the Fibrous Septa, the Deposits being surrounded by a Layer of newly formed Fibrous Tissue. (From an original drawing by the author: magnified about 500 diameters.)

Results.—Calcification is a final process, and is followed by no secondary changes. The calcareous masses, however, act as foreign bodies, and generally become capsulated by a band of new fibrous tissue. The effect of calcification upon the organ involved is a permanent loss of function, proportionate to the degree of the infiltration. In some instances the mere presence of the calcareous nodules can only be disastrous. Located in the large arteries, they cause dilatation of the heart, with embarrassment of the circulation, and may lead to hæmorrhage, thrombosis, or aneurism. In the smaller arteries they sometimes cause gangrene of the extremities. In the nervous system the evils attributed to the irritation caused by calcareous deposits are manifold: epilepsy, apoplexy, paralyses, angina pectoris, goître, etc. On the other hand, the effect of a calcification is often salutary, inasmuch as it checks the growth of tumors and prevents the occurrence of other more serious changes. An important exception to this is observed, however, in the case of myeloid tumors, of which the late Dr. S. D. Gross says: "The degree of malignity may be graded in accordance with the existence or absence of calcareous or osseous deposits." *James M. French.*

CALCIUM. 1. General Medicinal Properties of Compounds of Calcium.—In the group afforded by the metals of the alkalies and the earths, calcium is distinguished by the absence in its preparations of any active properties derived from the basic radicle. Lowness of diffusion power, and hence difficulty of absorption, slight local tendency to repress secretion, and slight constitutional tendency to oppose degenerative processes in tissues, constitute about all that is generally characteristic in the way of physiological influence in lime compounds as such. The general medicinal uses are, therefore, the application of these feeble powers under appropriate circumstances of disease, or, independent of them, the administration of calcic compounds for the sake of their nutritive value in conditions where the lime-salts, normal to the tissues, seem to be deficient. Individually, the calcic compounds differ greatly in their properties, and thus arise many individual therapeutic applications, to be noted under the several preparations.

2. The Medicinally used Compounds of Calcium.—The compounds of calcium that enter into the pharmacopœial preparations containing the metal are the *monoxide, hydroxide, carbonate, phosphate, hypophosphite, chloride, bromide, sulphide* (in the preparation *sulphurated lime*), and the compounds, whatever they be, that form the substance called *chlorinated lime.* The *sulphate* (gypsum), though not officinal, not being of use as a medicine, is yet of importance to the medical practitioner, because of its availability for purposes of surgical dressings. In the present article will be discussed only the *monoxide, hydroxide, carbonate, phosphate,* and *sulphate.* For the other compounds above cited see, respectively, Hypophosphites, Chlorides, Bromides, Sulphides, and Chlorine.

Calcic Monoxide: CaO. Calcic monoxide in the form of the ordinary "lime," or "quick-lime" of commerce, is officinal under the simple title *Calx,* Lime. It is officinally described as "hard, white, or grayish-white masses, gradually attracting moisture and carbonic acid gas on exposure to air and falling to a white powder, odorless, having a sharp, caustic taste and an alkaline reaction. Soluble in 750 parts of water at 15° C. (59° F.), and in 1,300 parts of boiling water; insoluble in alcohol. When heated to a white heat, lime is neither fused nor altered. Brought into contact with about half its weight of water, it absorbs the latter, becomes heated, and is gradually converted into a white powder (slaked lime)" (U. S. Ph.). Because of the strong affinity of lime for water, it should be kept in tightly closed vessels in a dry place. Lime is obtained from some of the varieties of native calcic carbonates by calcining.

Physiologically the importance of quick-lime lies in the fact that because of its intense affinity for water it is caustic. To a moist surface it is powerfully escharotic, but because of the solid and nearly insoluble product of its caustic action (slaked lime), such action is never spreading. In practice, because of its inconvenience of manipulation, quick-lime is rarely used by the surgeon, except in the form of the composite preparation, *potassa with lime* (Vienna caustic), for whose description see under Potassium.

Calcic Hydroxide: $Ca(OH)_2$. Calcic hydroxide is the familiar substance, *slaked lime,* which forms in the shape of a white powder as the product of the chemical reaction between lime and water. The reaction is attended by the development of a high degree of heat. Slaked lime is not officinal in the U. S. Pharmacopœia under

any distinctive title, but the preparations into whose composition it enters are defined as preparations of lime, simply. Slaked lime is a soft, white, bulky powder, of a mawkish, alkaline taste, and having the solubilities detailed above in the pharmacopœial description of lime. From its difficult solubility in water it is, although a powerful free base, yet not caustic to living tissue. From its combining, therefore, the properties of harmlessness with high basicity, it is valuable as an antidote—so far as antidotes go—in poisoning by acids, and is especially to be selected in cases of poisoning by oxalic or sulphuric acids, because of the great insolubility of the salts it makes with these several acids. For more properly medicinal purposes slaked lime is used in the valuable pharmacopœial preparation commonly known as *lime-water*, but officinally entitled *Liquor Calcis*, Solution of Lime. This is simply a saturated aqueous solution of slaked lime, easily made by any one by stirring freshly slaked lime into water—fairly pure water free from salts—in any proportion greater than one to seven hundred and fifty. The vessel containing the resulting solution is kept, with the excess of undissolved lime retained, tightly stopped, and after settling of the undissolved portion, the clear, supernatant liquor is drawn off in small quantities, for use, by decanting or siphoning. The object of having an excess of lime lies in the fact that lime-water has a great affinity for carbonic dioxide, absorbing this gas from the atmosphere and forming with it the insoluble calcic carbonate. By such reaction the lime of lime-water gradually becomes exhausted, but by the device of keeping in the containing vessel an excess of lime, the water of the solution recharges itself therefrom as fast as it loses strength by carbonating, and the solution of lime is so maintained steadily at saturation. Lime-water is "an aqueous solution containing about 0.15 per cent. of hydrate [hydroxide] of calcium." It is "a clear, colorless liquid, without odor, having a saline and feebly caustic taste and an alkaline reaction. Sp. gr. 1.0015 at 15° C (59° F.). When heated to boiling it becomes cloudy" (U. S. Ph.). Although clear when first made, lime-water, upon keeping, is certain to become turbid from absorption of carbonic dioxide from the atmosphere, and formation thereby of calcic carbonate. If, however, there be, as above advised, an excess of lime in the bottle, the turbidity does not mean loss of strength, and a sample so affected is perfectly good for medicinal purposes. Lime-water is incompatible with alkaline carbonates, sulphates, borates, salts of ammonia and the metals, acids and acidulous salts, and astringent vegetable decoctions or infusions.

Lime-water is, of course, alkaline, and at the same time is, physiologically, locally bland and soothing to irritation, and of a tendency to check secretion. Taken internally it tends to allay gastric irritability and to control diarrhœa, especially when the latter is caused by acidity of the intestinal contents. From the conjunction of properties named, lime-water is an excellent alkaline wash in skin disease, and is a standard remedy to subdue vomiting and combat the diarrhœa of acidity. In its internal use by far the best way of giving is in mixture with fresh, ice-cold milk. In such mixture, even when "half and half" in strength, the disagreeable lime taste is almost wholly lost, while at the same time, the medicinal efficacy of the lime is enhanced, and the patient is nourished by the milk. In obstinate vomiting, indeed, nothing surpasses the administration of small quantities of ice-cold lime-water and milk, frequently repeated, to the exclusion of all other medicine and nutriment both. In ordinary cases, the lime-water need not be in greater proportion to the milk than one part to two, three, or four. Such mixtures, if the stomach be not too sensitive, may be administered quite freely, but yet the *habitual* use of lime-water in milk, in milk-fed individuals, such as infants, is objectionable. For occasional use, lime-water is so innocent that it is hardly possible to assign any exact dose, but a tablespoonful generally suffices for a single giving, to be taken in at least an equal measure of water or milk. A special application of lime-water is based on the fact that the tissue of false membranes immersed in the solution rapidly disintegrates. Hence the practice with some to spray the throat, in croup or diphtheria, with atomized lime-water. In such procedure, however, it must be remembered that in the amount of spraying practically possible, the quantity of lime-water brought into contact with the membrane is very small, and the duration of such contact short.

Lime-water, although decidedly alkaline, yet yields, upon swallowing, so little alkali for ready absorption into the blood, that the preparation is practically useless for those purposes of constitutional alkalizing for which basic compounds of potassium and lithium are so efficacious.

Besides lime-water, the U. S. Pharmacopœia offers, as a preparation of lime in solution, *Syrupus Calcis*, Syrup of Lime. This syrup is made by treating a triturated mixture of lime and sugar with boiling water, and bringing the solution after filtration to the standard strength of five per cent., by weight, of lime. In this procedure the lime and sugar chemically unite, and the product, while retaining the alkalinity and physiological properties of free lime, is yet much more soluble in water, as the five per cent. strength of the syrup attests. Syrup of lime is, therefore, medicinally, a sweetened, and, at the same time, a strong solution of lime, and may be used for the internal applications of lime-water, only in much smaller dose—one-eighth, namely, of what would be given of the latter preparation.

For local application of the soothing properties of lime solutions, an excellent and ingenious preparation of lime is officinal in the U. S. Pharmacopœia under the title *Linimentum Calcis*, Lime Liniment, often called *Carron-oil*, from the Carron Iron-works, in Scotland, where the liniment acquired great reputation for the treatment of burns among the workmen. The preparation is simply an admixture, in equal parts, of lime-water and cotton-seed oil, whereby a lime soap is formed, which, being insoluble, makes an emulsion with the considerable excess of the oil which the formula provides for. The oil, however, readily separates from the aqueous portion, and hence the preparation should be ordered to be well shaken each time before use. Lime liniment combines the protection of a fixed oil with the alkaline and soothing properties of lime, and makes an excellent dressing for painful affections of the skin, such as burns, both allaying pain and promoting healing. It is applied clear.

Calcic Carbonate: $CaCO_3$. Calcic carbonate is represented in the U. S. Pharmacopœia by two preparations. *Creta Præparata*, Prepared Chalk, is "native, friable Carbonate of Calcium, freed from most of its impurities by elutriation;" and *Calcii Carbonas Præcipitatus*, Precipitated Carbonate of Calcium, is the salt obtained as precipitated from a solution of calcic chloride by reaction with sodic carbonate. Prepared chalk is in the form of powder, or of little conical pellets, and the precipitated carbonate is always in the condition of a very fine soft powder. Both preparations are permanent in air, odorless and tasteless, and insoluble in water or alcohol, although soluble, with effervescence, in hydrochloric, nitric, or acetic acids.

Calcic carbonate closely resembles slaked lime in its properties, but being a salt is less strongly alkaline, and being wholly insoluble in neutral fluids of aqueous basis, is, locally, absolutely bland. It is medicinally applicable, in a general way, for the same purposes as lime-water, and, in addition, because it is a bland, soft, and alkaloid absorbent powder, it makes an excellent "dusting-powder" to apply as a dressing to skin affections where the cutaneous surface is moist and tender. Internally the carbonate is available as an antidote to acid poisoning, especially if the acid be sulphuric or oxalic, and is of use to correct idiopathic acidity of the *primæ viæ*, and to allay nausea and check diarrhœa. Being perfectly innocent, either of the forms of the salt may be given freely. For ordinary use in digestive derangements the single dose ranges from 0.65 to 3.00 Gm. (ten to forty-five grains). The medicine may be given as a powder, but administration in mixture is more common. The following pharmaceutical preparations are officinal in the U. S. Pharmacopœia. *Pulvis Cretæ Compositus*, Compound Chalk Powder. This consists of three parts of prepared

chalk, two of powdered acacia, and five of powdered sugar, mixed. This powder is probably officinal as the basis for making the next named preparation, but yet is itself a convenient chalk powder for direct prescription. *Mistura Cretæ*, Chalk Mixture. This is compounded of two parts of the foregoing compound chalk-powder and four parts each of water and cinnamon-water. The sugar and acacia of the compound chalk powder dissolve and the slightly viscid solution resulting is capable, when shaken, of holding the chalk in suspension. The preparation should be freshly made for use, and should be shaken each time before dispensing a dose. It makes a very convenient basis for diarrhœa mixtures, especially in cases of diarrhœa with acidity. It may be given in tablespoonful doses. *Trochisci Cretæ*, Troches of Chalk. Each troche contains 0.26 Gm. (four grains) of prepared chalk with a flavoring of nutmeg.

Normal Calcic (*Ortho-*) *Phosphate:* $Ca_3(PO_4)_2$. This is the phosphate commonly called, for distinction, *bone-phosphate.* It is officinal under the title *Calcii Phosphas Præcipitatus*, Precipitated Phosphate of Calcium, and is made by dissolving the phosphate of bone-ash by means of hydrochloric acid, and then precipitating it from the solution by the addition of water of ammonia. Such precipitate, washed and dried, presents itself as "a light, white, amorphous powder, permanent in the air, odorless, tasteless, and insoluble in water or alcohol. Wholly soluble in nitric or in hydrochloric acid without effervescence. At an intense heat it is fusible without decomposition" (U. S. Ph.). When freshly precipitated and still moist this phosphate also dissolves wholly in lactic acid.

Calcic phosphate is an important normal ingredient of the animal body, being the calcareous element of the bones and teeth. The use of the salt in medicine has been its internal administration in conditions of disease where there appears to be a deficiency of the substance in the proper tissues, either from assumed lack of supply, or from want of power of assimilation. Such conditions are illustrated by rickets, mollities ossium, caries of the teeth, and possibly by scrofula and phthisis. But as often happens in medication based on purely chemical considerations, the clinical results frequently fall short of the expectation, so much so that many practitioners put little faith in the present remedy. Very likely the lack of effect of calcic phosphate is principally due to the difficulty of determining the absorption of the salt, partly because of the salt's entire insolubility in other than acid menstrua, and partly because of its low diffusion power. But inasmuch as the phosphate is wholly innocent, locally and constitutionally, it may with propriety be at least tried in cases where it seems theoretically indicated. From 0.65 to 2.00 Gm. (ten to thirty grains) may be given three times a day, larger doses being probably useless through lack of absorption. A convenient form of the medicine is the officinal preparation of the U. S. Pharmacopœia entitled *Syrupus Calcii Lactophosphatis*, Syrup of Lactophosphate of Calcium. A washed magma of freshly precipitated calcic phosphate is dissolved in lactic acid, and the solution diluted with water and orange-flower water, and rendered syrupy by a considerable addition of sugar. Should a gelatinous precipitate tend to form upon keeping, a fluidrachm of hydrochloric acid may be added to each pint of the syrup. This syrup contains twenty-two parts of calcic phosphate to the thousand, by weight; and may be given in doses of from two to four teaspoonfuls, representing from 0.20 to 0.40 Gm. (three to six grains) of phosphate.

Calcic Sulphate: $CaSO_4,2H_2O$. This salt is used in medical art only in the making of plaster-of-Paris dressings. Not being employed medicinally it is not officinal in the U. S. Pharmacopœia. Calcic sulphate occurs native in several conditions, the commonest being the salt combined with two molecules of water, constituting the substance *gypsum.* The valuable property of gypsum is that when dehydrated and treated with water, it recombines with the latter, and in such combining sets in a hard dry mass. Gypsum is dehydrated by heat, which should not exceed 120° C.; for if carried too high (above 200° C.) the gypsum—called then technically *dead-burnt*—recombines with water but slowly and the product does not solidify. As properly dehydrated and pulverized the product is a white powder, called *burnt gypsum* or *plaster-of-Paris.* This mixed with two parts of water makes a soft creamy paste, which in the course of from fifteen to twenty minutes gradually stiffens, until at last it sets into a perfectly hard and dry mass. During the setting a moderate degree of heat is evolved (not beyond the range perfectly bearable by the human skin), and the mass very slightly expands. Applied therefore as a casing to a limb, the dressing may be perfectly fitted without fear of shrinkage upon setting. After setting, the plaster-of-Paris neither softens nor dissolves by treatment with water, the solubility of calcic sulphate in water being only about one part in five hundred. For use in surgery, the plaster-of-Paris paste may be applied by smearing it upon the bandaged limb so as to form a casing, but a far better way is to impregnate a flannel bandage thoroughly with the dry plaster, roll it loosely, and when the dressing is to be fitted dip the roller into a vessel of water until bubbles cease to be evolved and then apply in the usual manner, but without reverses. Before so applying, however, the skin should be protected by a plain bandage, or, where appropriate, by a thread glove or a stocking.

Plaster-of-Paris should be kept in well-closed vessels, else, attracting moisture from the atmosphere, it will become partially hydrated. *Edward Curtis.*

CALCULI, CUTANEOUS. Cutaneous calculi, or stones of the skin, are usually composed of altered and hardened sebaceous matter contained in milia (see Milium). They are very rare. Forster (*Boston Medical and Surgical Journal*, January 30, 1879), has reported a case in which the tumor was of oval shape, about .16 centimetre in diameter, and of stony hardness. It occurred upon the temple, and on excision was found to consist of calcium phosphate with a small proportion of calcium carbonate, epithelial débris, and fatty matter.

Arthur Van Harlingen.

CALEDONIA SPRINGS. A saline spa situated on the Ottawa River, a few miles from St. Ann's, and about seventy miles from Montreal, Canada. In addition to three saline springs there is a fourth, a sulphuretted spring, which, however, is said to be losing its sulphurous properties. The saline waters contain also iodides and bromides. These are useful in various scrofulous skin affections, in certain anæmic conditions, in chronic rheumatism, gout, etc. (see art. Medicinal Springs).

The following is the composition of the different springs according to the analysis of T. Sperry Hunt. One pint contains, expressed in grains:

	Gas Spring. 44.5° F.	Saline Spring. 45° F.	Intermittent Spring. 50° F.	Sulphur Spring. 46° F.
Carbonate of sodium	.354	1.284	......	3.321
Carbonate of magnesium	3.834	3.769	6.294	2.142
Carbonate of iron	......	trace.	trace.	trace.
Carbonate of calcium	1.078	.856	.921	1.530
Carbonate of manganese	......	trace.	......	....
Chloride of potassium	.225	.219	.222	.167
Chloride of sodium	50.772	46.934	89.265	28.004
Chloride of magnesium	......	......	7.533	......
Chloride of calcium	......	......	2.091	......
Sulphate of potassium	.038	.035	......	......
Iodide of sodium	.003	.010	......	......
Iodide of magnesium	......	......	.015	......
Bromide of sodium	.109	.123	......	.073
Bromide of magnesium	......	......	.173	......
Alumina	.032	trace.	trace.	.019
Silica	.225	.309	.164	.612
Sulphate of sodium	......	......	......	.133
Total	56.670	53.539	106.678	36.001
Carbonic acid gas	5 cub. in.	4 cub. in.	......	2 cub. in.

T. L. S.

CALIFORNIA SELTZER SPRINGS. *Location*, Mendocino County, Cal.; *Post-office*, Sauel, Mendocino County, Cal.

ACCESS.—By San Francisco & Northern Pacific Railroad.

ANALYSIS (H. G. Hauks).—One pint contains:

	Grains.
Carbonate of soda	7.598
Carbonate of magnesia	10.118
Carbonate of lime	1.938
Carbonate of iron	0.567
Chloride of sodium	1.478
Alumina	0.075
Silica	0.729
	22.503
Carbonic acid gas	45 cubic in.

There are also minute quantities of carbonate of lithium, sulphate of lime, boric acid, and organic matter.

G. B. F.

CALISTOGA HOT SPRINGS. *Location and Post-office*, Calistoga, Napa County, Cal.

ACCESS.—By California Pacific & Northern Division of Central Pacific to Calistoga.

ANALYSIS (F. W. Hatch, M.D.).—One pint contains:

	Grains.
Carbonate of soda	0.425
Chloride of sodium	2.781
Chloride of calcium	0.408
Sulphate of soda	0.202
Sulphate of magnesia	0.058
Silica	0.812
Alumina	trace
	4.686
Sulphuretted hydrogen gas	0.40 cubic in.
Temperature of water, 97° F.	

THERAPEUTIC PROPERTIES.—These are thermal sulphur waters. There are some sixty springs, of different temperatures, ranging from lukewarm to the boiling-point. Bathing is the treatment almost entirely adopted, and commodious arrangements are at hand for the application of the baths in the form of water and mud. The property is lavishly improved, and contains, among other attractions, an extensive vineyard, affording an opportunity to test the "grape cure." *G. B. F.*

CALLOSITAS. Callositas may be defined as a superficial, flattened, thickened, more or less circumscribed, grayish or yellowish-brown, horny patch of epidermis.

The beginning of the affection is characterized by slight thickening of the skin, with no perceptible change in texture; if the cause continues to operate, the parts become hard, horny, elevated, and considerably thickened. In moderately developed cases the lines and folds of the skin remain undisturbed; in marked examples of the affection these are no longer perceptible, the surface becoming smooth and horny. Later the accumulations may be so increased and unyielding as to impair motion, or if motion is made, deep cracks and fissures are produced. In rare instances, especially if an accidental injury is superadded, the pressure of the mass upon the underlying corium provokes inflammation and suppuration, in consequence of which the horny plate is cast off in its entirety. The patches are ordinarily of the size of a coin, more or less rounded, slightly elevated, with the thickness greatest at the centre. The color varies from a grayish to a brownish tint, depending, to a certain extent, upon the amount of pressure and friction to which the parts have been subjected, and upon the occupation of the patient. They are usually seen upon the hands and feet, particularly those parts exposed to pressure and friction. They occur, in varying degrees, upon the hands of all whose labor is chiefly manual, especially those who use tools: carpenters, shoemakers, smiths, and laborers are seldom free from these epidermic hypertrophies.

The main factor in the production of a callosity is intermittent pressure or friction. Thus the use of tools and such implements gives rise to patches on the hands, while those on the feet arise from the pressure and friction of ill-fitting shoes. It is to be stated, however, that in exceptional instances the callosities appear without apparent cause, and usually in such cases the growth is excessive. It may be added also that the same amount of pressure and friction in different individuals rarely provokes the same degree of callosity. These facts show that although external causes are mainly responsible for these growths, yet that there must be other etiological factors which take part in their production.

Anatomically a patch of callosity is found to be made up of an accumulation of layers of epithelial cells of the epiderm. A section will show hypertrophy of the horny layer, the corium remaining normal. The cells may be so closely packed as to simulate horn substance.

In ordinary cases no treatment is called for, as the process is to be considered as conservative, inasmuch as it protects the more sensitive corium from injury. Where the hypertrophy is excessive, inconvenient, or disfiguring, remedial measures are demanded. The parts are first to be softened by means of hot water, warm fomentations, or poultices; subsequently the mass can be readily pared or scraped away. A solution of caustic potash will frequently be found sufficient to remove the accumulations; it must be used with care. Sapo viridis will act in the same manner if kept constantly applied in the form of an ointment. A plaster made of salicylic acid and gutta-percha, bound down to the parts and changed every few days, will remove the mass. Solutions of ten to twenty per cent. strength of salicylic acid in alcohol or collodion will be found efficacious. A removal of the cause is invariably followed by a spontaneous disappearance of the callosity. *Henry W. Stelwagon.*

CAMPHOR (*Camphora*, U. S. Ph., Br. Ph., Ph. G.; *Camphre du Japon*, Codex Med.). A stearoptene or solid essential oil, obtained by distillation from the wood of *Cinnamomum Camphora* Nees and Eberm. (*Laurus Camphora* Linn., *Camphora officinarum* Nees); Order, *Lauraceæ*. This is a medium- or good-sized tree, of slender habit, with long, horizontal, smooth, green branches, and a hard, light-colored, very fragrant and valuable wood. The alternate evergreen leaves are dark and shining above, lighter, glaucous-green beneath, ovate acuminate entire, three-nerved. Flowers minute greenish-yellow, in small axillary panicles. Perianth thick, six-lobed stamens, nine with four-celled anthers opening by valves. Staminoides six. Ovary free, one-celled, one-seeded. Fruit about as large as a pea, surrounded by the persistent perianth tube. This tree grows extensively and abundantly in Formosa and the Japanese islands, from which places all the camphor of European and American commerce is obtained; and in Central China. It has also been transplanted and flourishes in most tropical or subtropical countries of both hemispheres.

FIG. 557.—Camphor Tree, Flowering Branch. (Baillon).

Camphor was known in Europe in the twelfth century, how much older its use was in Asia is difficult to say, as several other similar and more highly prized camphors have been known there from a remote period, and the older notices of camphor appear to have reference to them.

COLLECTION.—In Formosa, long wooden troughs (often made by hollowing out logs), protected by clay from the

action of fire, are arranged over a sort of furnace. They are partly filled with water and then board-covers perforated with numerous holes are luted over them. Small piles of the camphor-wood, cut into chips, are arranged on these boards, and each covered with an inverted earthen pot. The fire is then built, and as the water boils the steam passes up through the chips, carrying the volatilized camphor with it. This condenses in the upper, cooler part of the pots, and as it accumulates is scraped out and the supply of wood renewed. In Japan the chips are boiled in iron kettles with condensing arrangements placed over them. The camphor thus obtained is in a coarse crystalline powder, whose granules afterward aggregate more or less into larger masses. It is grayish-white or pink in color and contains both chemical and mechanical impurities. While lying in vats or bins, previous to being boxed or packed for export, a small quantity of essential oil, also an article of commerce—*oil of camphor*—drains out. Formosa camphor is systematically wetted before packing for transportation in order to retard evaporation. Japan camphor, which is usually a rather cleaner, better variety, is sent out dry. Both camphor and its oil need purifying for use—the latter is simply redistilled, the former is resublimed after being mixed with sand, charcoal, or lime. In Europe this is done in large spherical glass flasks, in the top of which the vapor condenses into a concave or plano-convex mass, which is removed by breaking the vessel. In this country it is done in a sort of retort with a flat iron cover, on the bottom of which it collects in a round cake, about as large as a barrel-head and one inch or more thick, with a hole in the centre. In this form it is now universally found here. The enormous use of camphor for domestic purposes has very much improved and cheapened the processes of purification within a few years past.

Purified camphor is in white, translucent, slightly flexible, crystalline masses of well-known taste and smell, traversed by innumerable fine fissures, and easily rubbed to pieces between the fingers, but impossible to pulverize by itself. It evaporates slowly at ordinary temperatures, and if kept in a closed vessel gradually distributes itself over its sides in fine crystals; small bits thrown upon water revolve and move about upon its surface. Its specific gravity is about the same as that of water, in which it also dissolves to the extent of one part in thirteen hundred (Aqua Camphoræ, U. S. Ph.). In alcohol, ether, chloroform, fatty and other essential oils it is freely soluble. With chloral hydrate it forms a liquid combination, with pyroxylin it composes the substance known as "celluloid," which is considerably used for combs and other toilet conveniences.

In composition camphor is closely related to the numerous terpene series of essential oils, and still closer to cymene, $C_{10}H_{14}$, the basis of many mint and other oils, of which it may be considered to be a hydrate ($C_{10}H_{14} + H_2O = C_{10}H_{16}O$ = camphor).

Action and Use.—Camphor is very deleterious to insects of all kinds, and on this account is in universal domestic use to preserve woollen clothing from their attacks. For this purpose probably ninety-nine hundredths of the camphor used in this country is consumed. In warm-blooded animals it produces very generally, in large doses, convulsions and coma of epileptiform character and undoubted cerebral origin. It also depresses the heart. Upon man the symptoms of poisonous doses are similar—vomiting, dizziness, slowing of pulse, fainting, headache, delirium, convulsions, coma, small pulse, prostration, and gradual recovery; no fatal case has occurred of camphor poisoning pure and simple. After smaller doses the symptoms are a comfortable feeling of exhilaration and quiet, due to its stimulating effect upon the brain. It is claimed, with doubtful right, to be an anaphrodisiac. Camphor is considerably given to quiet restless and nervous patients, generally in combination with other antispasmodics; with opiates it is sometimes useful in nervous headaches, and also with opium it is a universally used ingredient of diarrhœa and colic mixtures, which it improves by its locally carminative action. In hysterical attacks, excessive nervous excitement accompanied by debility, undue sexual excitability, and similar conditions, it is moderately beneficial. It is also a favorite ingredient of liniments. Dose: From three to five decigrams (0.3 to 0.5 Gm. = gr. v. ad viij.) is as small a dose as will produce any noticeable physiological effect, and a suitable one for continuous administration; for immediate effect, from one-half to one gram (0.5 to 1 Gm. = gr. viij. ad. xv.) will be required. Much larger doses might be followed by unpleasant effects. It can be given in pill or suspended in mucilage or syrup. Large doses should be well diluted. There are numerous preparations. 1, Camphor Water (*Aqua Camphoræ*, U. S. Ph.), a saturated solution used as a vehicle (a pint containing only about a dose of camphor); 2, Camphor Liniment (*Linimentum Camphoræ*, U. S. Ph., $\frac{1}{5}$ camphor in cotton-seed oil); 3, Soap Liniment (*Linimentum Saponis*, U. S. Ph., $\frac{4}{100}$ camphor); 4, Spirits of Camphor (*Spiritus Camphoræ*, U. S. Ph., camphor $\frac{1}{10}$ in spirit), a generally used and grateful toilet preparation; and 5, Paregoric (*Tinct. Opii Camphorata*, U. S. Ph.), where it is merely used as a subordinate adjuvant.

Allied Plants.—See Cinnamon.

Allied Drugs.—Many of the essential oils. Thymol and menthol are closely analogous substances. More remotely, camphor, in its medical uses, may be compared with musk, valerian, assafœtida, and other antispasmodics, and with caffeine in some respects. Borneo and N'Gai camphors are stearoptenes of other Asiatic trees, resembling common camphor in the main, but different in odor and in other particulars. They never reach America or Europe, excepting as costly museum specimens, as they are enormously prized at home.

Oil of camphor has the same medicinal qualities as camphor itself. *W. P. Bolles.*

CANELLA BARK (*Canellæ Albæ Cortex*, Br. Ph.; *Canelle Blanche*, Codex Med., Wild Cinnamon) is the bark of *Canella alba* Murray; Order, *Canellaceæ*, deprived of its outer portion. This is a handsome, middling-sized, spicy, evergreen tree, with thick, shining, aromatic leaves and small, purple, deliciously fragrant flowers. The bark of the smaller branches is silver-gray. It is a native of the West India Islands, especially of Jamaica, Cuba, and the Bahamas, and also of the southern part of Florida. The bark of this tree was first made known in Europe in the early part of the seventeenth century, and since then has been in continuous but very limited demand. It has been frequently confounded with Winter's Bark (*Drymis Winteri* Foster), and with *Cinnamodendron corticosum* Miers. It is now very little used excepting in its home, where it is highly esteemed.

Before the bark is collected the limbs are generally beaten all over, in order to loosen the outer layers, which are discarded, and then the inner portion is separated in quills and chips and dried. It comes in broken quills; sometimes thirty or forty centimetres long and one-half of one thick (twelve to fifteen inches by one-fourth inch), but averaging much smaller, say from five to ten long by two or three millimetres in thickness; the outer surface is roughish and bright buff-colored, the inner smooth or finely striated, yellowish or creamy white; fracture short and granular, odor rather agreeable, cinnamon-like; taste pungent and bitter. It contains numerous large oil-cells, especially in the outer portion.

Composition.—The leading constituent is the *essential oil*, of which it contains from three-fourths to one per cent. It is a composite oil, capable of being separated into several, one of which is *eugenol*, the leading ingredient of oil of cloves. A considerable percentage of Mannite can also be separated. The bitter principle needs further study. Canella is a stimulant tonic, similar to other aromatics, over which it appears to have no other advantage than the possession of a bitter principle. It is used in the British Wine of Rhubarb (*Vinum Rhei*, Br. Ph.) as a corrigent. Calamus has taken its place in that of the United States. It is not poisonous, is seldom given alone, and has no special dose.

Allied Plants.—*Cinnamodendron corticosum* Miers, another tree of the same order, growing in Jamaica, fur-

nishes a coarse, redder bark of similar qualities and uses, not employed outside of tropical America. The order consists of only four or five plants, all tropical American.

Allied Drugs.—Aromatics, spices, and aromatic bitters. See Cinnamon, Ginger, Magnolia, Cascarilla, etc. *W. P. Bolles.*

CANITIES (from *canus*, white). Blanching or graying of the hair. When occurring in advanced age it may be considered physiological, and the premature graying of the hair is alone to be considered in this article. Gradual premature graying of the hair is often entirely unaccompanied by other disease of the hair, the latter retaining its fulness upon the scalp (with which we are chiefly concerned) until advanced age. It often seems to depend upon some idiosyncrasy in the individual.

Sudden graying of the hair, over night for instance, has long been popularly believed possible. Scientific men, and especially German writers on dermatology, have, however, until recently scouted the idea. Kaposi ("Pathologie und Therapie der Hautkrankheiten," 2te auflage, 1883) still maintains the physiological impossibility of such a change in the hair. On the other hand, however, such a trained observer as Brown-Séquard has reported his personal experience, showing that a graying of the hair over night can certainly occur. In the light of the now-established fact older observations have renewed interest. History tells of numerous famous persons in whom the hair has suddenly turned gray. Sir Thomas Moore and Marie Antoinette, on the eve of their respective executions, are said to have presented this phenomenon, and other persons have shown the same conditions as a result of fright or anxiety.

Graying of the hair has been observed to supervene gradually as the result of various changes in the nervous system. Insane persons, especially melancholics, and also those affected by other central and peripheral nervous affections, show premature graying of the hair. Thus hemiatrophia facialis, and long-continued and frequently-recurrent attacks of neuralgia are also at fault.

General diseases are also at times accompanied or followed by graying of the hair, which, however, occurs in a different manner from that above described. Compagne, quoted by Michelson reports the case of a woman thirty-six years of age, in whom the hair began to blanch on the twenty-third day of a severe fever, and six days later was perfectly white. On the seventh day, however, the color began to darken and by the end of another week the hair had entirely recovered its original color. A young woman under my care, with alopecia areata, recovered after a time the growth of hair, but the hair over the affected patches at first came out gray. After a time it changed to a chestnut brown and finally, after some months, took on its normal bright red color. As brown hair is believed to contain more pigment than red, possibly an excess of pigment may here have been first deposited, and then an equilibrium established later. A young woman who had long been under my care for lupus erythematosus of the scalp finally recovered and hair grew once more over the former bald spots. The hair here was more wiry and sparse than elsewhere upon the scalp, and was of an iron-gray color, while the rest of the hair was brown.

In connection with the restoration of color in hair which has once become blanched, the following recently-published case is of high interest. An idiotic girl of thirteen under observation in an asylum at Hamburg, suffered from epilepsy with alternations of agitation and calmness, each of about a week's duration. The color of the hair underwent decided changes. Sometimes it was blonde, and at other times red, while the depth of these colors also varied. The alterations of color occurred in the brief space of two or three days; the first appearance of change was observed at the free ends of the hairs; the same tint of hair persisted for seven or eight days. Each of these periods of change of color of hair coincided with a phase of agitation or quietness. During the stage of excitement turgescence and redness of the face were pronounced, the pulse was full, and the skin warm and transpiring. The hair at this time always had a red color, while during the phases of stupidity the blonde tint prevailed. The paler hairs differed from the darker ones only in the presence of more numerous air-spaces.

Cases have been reported by Erasmus Wilson and others, in which the hair has grown in alternate bands of gray and dark color. Landois suggests that in these cases an intermittent action of trophic and vaso-motor nerves is exercised upon the hair, so that a hair-tissue is formed, within which periodical interstitial development of gas or air occurs.

No known means exist whereby the color of the hair can be influenced in its development. The action of hair-dyes depends upon a chemical effect produced upon the tissue of the fully-developed hair, which effect, in properly made dyes, is not produced upon the epidermis of the skin. As the hair grows daily, the dye is scarcely dry upon that part which appears above the surface before a new undyed section of hair pushes up from below, and the operation, of course, must be frequently repeated.

Arthur Van Harlingen.

CAÑON CITY SPRINGS. *Location and Post-office*, Cañon City, Tremont County, Col.

Access.—From Denver by Denver & Rio Grande Railway.

Analysis (Professor Lowe).

Salts.	Iron Duke. (Cold.)	Little Ute. (Cold.)	Ojocaliente. (Hot, 104° F.)
Chloride of sodium	83.0	118.0	18.2
Sulphate of soda	12.2	12.1	79.3
Carbonate of soda	76.8	76.4	73.2
Carbonate of lime	33.0	22.5	33.5
Carbonate of magnesia	14.6	14.0	12.8
Iron	traces.	traces.	....
Lithia	traces.	traces.	traces.
Total grains salt in one gal.	219.6	243.9	217.0

The Princess (cold), the latest spring, has not as yet been analyzed, but is considered superior to the others.

Therapeutic Properties.—The cold springs, containing common salt in marked proportion and carbonate of soda in appreciable amount, are alkaline-saline. Taken in moderate quantity they are refreshing and tonic, in excess they are cathartic. The value of the hot springs as a bath in chronic rheumatism and cutaneous affections is widely known and employed. The moderate altitude, compared to other similar resorts in the region, is in their favor.

The hot springs are on the south bank of the Arkansas River, a mile above the city, and issue from a conglomerate stratum. The cold springs are within the city limits, and flow from a sandstone formation. Cañon City is at an altitude of five thousand feet, near the Arkansas River, which is here a mountain stream, and from which the water-supply for the city is obtained. The climate is dry and invigorating, having a mean temperature of 58° F. The scenery of the surrounding region is grand. The celebrated "Grand Cañon of the Arkansas," where the river flows between perpendicular walls of rock two thousand feet high, is not far from the city. There is good hunting and fishing, and the hotel accommodations are excellent. There are churches of the various denominations, and good public and private schools in the city.

George B. Fowler.

CAOUTCHOUC, Codex Med. (India Rubber, Gum Elastic, etc.). A hydrocarbon of remarkable elasticity and insolubility, found in the milky juice of a number of tropical plants, belonging chiefly to the orders, *Apocynaceæ, Asclepiadaceæ, Euphorbiaceæ,* and *Urticaceæ.* The more important genera are as follows:

1. *Apocynaceæ. Landolphia* (*Vahea, Willoughbeia,* etc., are synonyms), a genus containing sixteen climbing shrubs of Africa and Madagascar, supplies Mozambique and other varieties of African Rubber. *Carpodinus* is also a reputed source of the above. *Hancornia speciosa* Gam., a medium-sized Brazilian tree, cultivated more for its edible fruit than for its juice, supplies a small amount of inferior "Pernambuco" Rubber. Several species of *Alstonia,* including *A. Scholaris* R. Br., the "Dita" tree,

yield it in various Pacific islands. *Urceola esculenta* Benth., a rapidly growing Indian tree, is beginning to be cultivated for this substance.

2. The order *Asclepiadaceæ* includes numerous plants containing rubber, but no very important ones; *Cryptostegia* and *Cynanchium* furnish some varieties from the East.

3. *Euphorbiaceæ.* Some of the most valuable sources of rubber are in this family; *Hevea* (syn., *Siphonia*), comprising nine closely connected species of South American trees, with branching trunks, minute flowers, and long-stemmed trifoliate leaves, supply most of the best South American (Pará) rubber—a portion of which, however, comes from the neighboring Brazilian genus, *Micrandra. Manihot* contains a number of sources of Caoutchouc.

4. *Urticaceæ.* A number of species of *Ficus* (Fig), especially *F. elastica*, supply most of the Indian Caoutchouc. *Castilloa*, of which there are two or three species, yields most of the Central American product. Besides these, one or two lobeliaceous and composite genera are reputed to contain the same material.

History.—India-rubber balls were made and played with in the West Indies as long ago as the discovery of these islands, and travellers and scientific persons during the next two hundred years now and then mentioned rubber, and described some of its primitive applications, but it was not generally known or used in Europe until near the beginning of the present century, when little bits of it became popular as erasers, and gave it its present most popular English name. Its applicability to waterproof shoes and other garments, however, soon increased the demand for it, and the discovery by Goodyear and others of its behavior with different proportions of sulphur—increasing its elasticity and permanence, or making it as hard as bone—has made it almost universal in its applicability. There is scarcely a substance used in the arts for such a diversity of purposes.

Preparation.—The essential features of its preparation are, tapping the trees (in the bark of which the milky liquid usually flows) and collecting, and suitably drying it. The details of the operation, as may be supposed, are different in different countries. The rubber of Pará, which is the best in the world, is gathered in the following way: A horizontal incision is made partly around the trunk, and above this a vertical cut with several oblique ones running into it. Small earthen cups are then fastened below so that the "milk" will flow into them. This milk, containing about one-third of its weight of caoutchouc, is collected day by day as long as it exudes, and dried in successive thin layers over a fire in which certain oily nuts are being heated, by dipping a clay mould mounted on the end of a stick into it and then holding it in the smoke or vapor of the fire, turning it to expose all parts equally to the heat until it is dry. The mould, with its layer of caoutchouc, is then dipped again, or the liquid is poured over it, and again exposed to the fire; this process is repeated again and again, until a sufficient thickness is obtained, when the original mould or core is crumbled and separated, leaving the rubber in some sort of hollowed form. These shapes are sometimes rude and fantastic imitations of birds or animals, more often balls, bottles, or cups; often split or cut to facilitate removal. Inferior sorts, made of scrapings from the tree, and other refuse rubber, are rolled into balls. Ceara Rubber is collected by wounding the bark of the trees, and allowing the liquid caoutchouc to exude in tears and flow down its sides. These, when dry, are stripped off in long, elastic threads and rolled into balls. This is also a very good variety. The Pernambuco rubber is prepared by coagulating the juice with alum, and drying the "curd" in cakes or sheets; it is a poor kind.

In Central America the liquid yield is also coagulated by the juice of some other plants, or by the addition of water. In some parts of Africa it is said to be collected by allowing the juice from the wounded trees to flow and dry over the arms of the gatherers and then peeling it off. In India it is coagulated by being poured into hot water; in Borneo salt water is used.

Rubber is valued in proportion to its elasticity, and the absence of moisture; the varieties collected by drying, are superior to those prepared by any form of coagulation.

Description.—Crude rubber comes in such numerous varieties, and in such shapes and grades, that a description of them would be beyond the scope of this article. Suffice it to say that it is found in hollow or solid forms, balls, cakes, sheets, and irregular masses, of a variety of colors, from nearly white to nearly black, through shades of pink, clayey brown, and gray. That which is prepared in layers, like the Pará variety, shows, on being cut, the concentric deposits of which it is composed by variations in color. It is at ordinary temperatures very tough and elastic; when very cold it is hard but not brittle; with moderate heat it melts into a thick syrupy liquid, but becomes somewhat decomposed, and on cooling has lost most of its elasticity and remains sticky.

Composition.—The fresh juice (latex) contains the cacutchouc (from ten to forty per cent.) in the form of an emulsion, that is, suspended like butter in milk, or salad-oil in Mayonnaise dressing—in minute, round globules. Besides the caoutchouc, the milk contains bitter, extractive, albuminous substances and other things. Upon standing it curdles like milk, the caoutchouc constituting the "curd."

Caoutchouc, when pure, is a white, odorless and tasteless at ordinary temperatures, very elastic substance; specific gravity, 0.94. It absorbs ten per cent. of water or alcohol, but is not soluble in either. It makes imperfect (turbid) solutions with ether, oil of turpentine, carbon bisulphide, naphtha, etc., and melts at a little above the temperature of boiling water, but remains inelastic and sticky after cooling. It is scarcely changed by dilute acids or alkalies, although decomposed by some of them when concentrated. By age it becomes hard and brittle. Although not dissolved by fatty oils, it is eventually made "rotten" and brittle by long contact with them, as when used in catheters, syringes, etc. The dark color of crude rubber is usually attributed to lamp-black or soot, collected in the course of its preparation or afterward added. It contains besides, various proportions of mucilage, extractive matters, and coarse mechanical impurities.

"Vulcanite," "Ebonite." The discovery that rubber would combine with, or at least dissolve, a certain amount of sulphur, with the effect of hardening it, making it more elastic and more durable; or under other circumstances making it a permanent, indestructible, ivory-like solid, has increased its usefulness and consumption nearly a hundred-fold, and given it the most versatile and marvellous adaptability. This is effected usually by incorporating a certain amount, say for soft articles ten per cent., of sulphur with the rubber, mechanically, by means of grinding or kneading mills, and then heating to a temperature of about three hundred degrees Fahrenheit. There are also other ways of effecting the mixture. By increasing the amount of sulphur, say to forty per cent., and the subsequent heat, the hard rubber or "ebonite" is obtained. When rubber is to be moulded it is made into shape while soft, by being forced into moulds, and heated, still in the same moulds, until it is "vulcanized."

Uses.—The numerous uses to which caoutchouc is put in every direction are generally well known, and it is only to those of medicine or surgery that reference will here be made. It has even, and that recently, been proposed as a medicine (in the treatment of consumption), for which it is needless to say it has not the least value, being absolutely insoluble in all the fluids of the body. Neither is it, as is popularly supposed, poisonous, excepting as a mechanical obstruction, which it might easily be. It is inert. It is used as the adhesive basis of a number of popular plasters, and for this purpose is far better than any other substance, with only this disadvantage, that they cannot be made extemporaneously (requiring, as they do, heavy mixing and spreading machines), and it is, therefore, only useful for such plasters as supply a continuous and large demand.

Plasters of cantharides, belladonna, capsicum, and others, prepared with more or less rubber, are in the market, and are very good. But the most useful application in this direction is the adhesive-plaster for surgical pur-

poses, especially for apparatus of extension and fixation, offered to the profession by Dr. H. A. Martin (*Boston Medical and Surgical Journal*, October 11, 1877). It is ideally perfect, very adhesive, unirritating, unchangeable. The composition is stated by Dr. Martin to be essentially Pará rubber, Burgundy pitch, and balsam of Tolu, mechanically ground together and spread on heavy unsized cloth under great pressure. Esmarch's elastic bandage and tourniquet for bloodless operations, and the same Dr. Martin's elastic bandage for continuous pressure in the treatment of varicose veins and ulcers, synovitis, etc., are also well known. In the manufacture of orthopedic appliances, nipples, syringes (hard and soft), pessaries, artificial teeth, specula, catheters, etc., the use of rubber needs only to be hinted at. Articles of rubber, either hard or soft, should be kept in a closed box or drawer, and occasionally used or washed, to prevent their becoming too dry and brittle. Silver instruments should never be kept in the same enclosure with them. Soft rubber is spoiled after a short time by oils and fats, and eventually hardens in spite of all precautions.

ALLIED SUBSTANCE.—GUTTA-PERCHA.

W. P. Bolles.

CAPE MAY. (Detailed explanation of the accompanying chart, and suggestions as to the best method of using it will be found in the article on Climate.) Cape May, at the southern extremity of the State of New Jersey (Lat. 38° 56′ N., Long. 74° 58′ W.), has had for the past one hundred years a great and well-deserved reputation as a summer seaside resort. More recently its comparatively mild winter-climate has given the place a reputation as a sanitarium during the colder months of the year. In point of temperature the climate of Cape May is very similar to that of Atlantic City, but both during the winter and the summer seasons the average temperature of the former place is rather warmer than is that of the latter (the greater difference between the averages of the two places occurring during the winter season), while the equability of temperature at Cape May is at all seasons more marked than is the same climatological factor at Atlantic City. The situation of Cape May, at the very tip of the peninsula, which has not inaptly been styled the "thumb of New Jersey" (a peninsula some fifteen miles long, and having an average width of about eight miles, which extends in a southwesterly direction from the mainland between the Atlantic Ocean and Delaware Bay), insures to the place the possession of a more distinctively insular or maritime climate than is to be found at any coast station on the Atlantic seaboard of the United States, with the possible exception of such stations as lie actually upon islands which are separated from the continent by a considerable interval of salt water. All stations of the latter class, lying at a considerably higher latitude than does Cape May, and being, moreover, much more directly exposed to the cold current which intervenes between the shore of our Northern seaboard States and the warm waters of the Gulf Stream, they are necessarily liable to far greater depressions of temperature both in winter and in summer than are ever experienced at Cape May.

With the exception of those coming from a northerly and northeasterly direction, all winds blowing at Cape May are necessarily more or less tempered by their passage over large bodies of salt water. All such as come from points between northeast and south are ocean-winds. The nearest point of land in a southwesterly direction from Cape May is Cape Henlopen, on the Delaware coast, distant no less than twelve miles in a line drawn directly across the mouth of Delaware Bay. A wind coming from the west would have to traverse eighteen miles of the waters of the bay after leaving the Delaware coast before reaching Cape May, while a northwest wind would blow very nearly in the direction of the long axis of the bay, no less than forty-five or fifty miles in length, and not only would have its temperature considerably modified by passing over so large an area of sea water, but would undoubtedly be very thoroughly impregnated with saline exhalations from the waters of the lower and wider part of the bay, and from the extensive salt marshes lining both shores of the upper and narrower half of this great pear-shaped, or gourd-shaped, arm of the sea. The average width of the southeasterly half of Delaware Bay is about twenty miles, that of its northwesterly prolongation may be estimated at some six or eight miles. This portion of the bay is, perhaps, more properly to be reckoned as the funnel-shaped and expanding mouth of the Delaware River. The salt-water marshes which line both its shores are about three or four miles wide along its northeasterly or New Jersey, and somewhat narrower along its southwesterly or Delaware shore; so that, taking water surface and marsh surface together, the total width of salt-water evaporation area presented by the narrower part of the bay from bank to bank, may be estimated at from ten to fifteen miles. As already mentioned, in the article on Atlantic City, a similar strip of marsh land extends along the eastern or Atlantic coast of Cape May Peninsula. Upon the Atlantic side of the peninsula this strip is about four miles wide; upon the bay side extends a similar but much narrower strip, not more than a mile wide. The geological map of the State of New Jersey accompanying the "Annual Report of the State Geologist for the Year 1881" shows that the backbone of the peninsula is occupied by "oak land" soils, which extend down to its very tip, where Cape May City and Cape May Point are situated.

"The soil which underlies Cape May is mostly gravelly, with sand under the gravel beds, and then another layer with bay-shore gravel. The water supply is well managed, and of excellent quality. It is derived from three sources. Two of these are large circular wells which go down into the gravel-bed and are not in the same stratum as the old wells of the town. These strata are divided by a narrow strip of clay so hard as to need the pick in excavation. The water from the upper well is pumped up by the Holly system into the tank at the lower well, and from both these is a supply sufficient for the ordinary uses of the city. About sixty feet from the second gravel-bed well is an artesian or bored well ninety-seven feet deep. . . . The water is pumped by steam to a tank thirty-four feet high, having a capacity of sixty thousand gallons. There is also another tank with a capacity of thirty-five thousand gallons. The steam-pumps can raise about twelve hundred gallons per minute. All whom I have been able to consult regard the supply as inexhaustible. The water is soft and pleasant to the taste" ("Sixth Annual Report of the Board of Health of the State of New Jersey, 1882"). Cape May Point and Cape May City lie respectively upon the southwestern and the southeastern aspect of the extremity of the peninsula, and are but three miles distant one from the other. Taken together they constitute the seaside resort known as Cape May. The "Eighth Annual Report of the State Board of Health, 1884," speaks well of the system of drainage in vogue at the former place, a system which, from the account therein given, appears to be similar to that which is adopted at Atlantic City. The report also commends the drainage system of Cape May City. In both instances a caution is introduced warning hotel proprietors and others not to rely too much upon the mere perfection of the sewerage arrangements established by the health authorities. On page 143 of this same Report the secretary of the Board of Health of Cape May County, Dr. H. A. Kennedy, alludes as follows to the water supply and drainage of Cape May City: "Our water supply is ample and good, there being no change since last report. Sewerage system has proven satisfactory, and since last year's improvements has not needed any attention."

A great deal of useful and interesting information respecting the climate of Cape May, and of other parts of New Jersey, is to be found in the "Appendix" to the "Annual Report of the State Geologist for the Year 1881." This "Appendix," written by Professor J. C. Smock, the Assistant State Geologist, has already been referred to and quoted from in the article describing Atlantic City, and the writer of the present article is much indebted to Professor Smock, not only for having supplied him with a copy of the above-mentioned Report, but also for having

very kindly furnished other valuable assistance in the task of describing the health resorts of New Jersey, and in particular for having obtained for him from the Chief Signal Office the large climatological charts accompanying this present article and the article upon Atlantic City.

This Washington chart for Cape May is here introduced, and an examination of its figures will bear out, so far as they go, what has already been said concerning the climate of this justly celebrated resort.

It is proper at this point to introduce a word of caution to any who may be disposed to compare these Signal Office charts for Cape May and for Atlantic City, column by column, with other similar charts published in this HANDBOOK; and that is, that they will please observe that the two columns lettered respectively "G" and "H" cannot justly be compared with the "G" and "H" columns of the other charts, inasmuch as the standard upon which the figures of these columns are based in the two charts now under consideration is not identical with the one adopted in the others.

Climate of Cape May, N. J.—Latitude 38° 56′, *Longitude* 74° 58′.—*Period of Observations, June* 1, 1871, *to December* 1883.—*Elevation of Barom. Cistern above the Sea Level,* 27 *Feet.*

	A			AA	B		C	D	E		F		G	H
	Mean temperature of months at the hours of			Average mean temperature deduced from column A.	Mean temperature for period of observation.		Average maximum temperature for period.	Average minimum temperature for period.	Absolute maximum temperature for period.		Absolute minimum temperature for period.		Greatest number of days in any single month on which the temperature was below thirty-two degrees.	Greatest number of days in any single month on which the temperature was above ninety degrees.
	7 A.M. Degrees.	3 P.M. Degrees.	11 P.M. Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Degrees.	Degrees.	Highest. Degrees.	Lowest. Degrees.	Highest. Degrees.	Lowest. Degrees.		
January	31.9	36.6	34.1	34.2	43.2	28.6	41.2	29.4	58	43	18	1	26	0
February	33.1	38.6	35.3	35.6	41.7	28.0	45.0	31.8	59	42	23	2	22	0
March	37.9	42.9	39.6	40.1	47.7	33.3	47.7	35.1	65	48	25	9	16	0
April	45.9	51.2	47.2	48.1	54.7	44.0	54.8	43.0	76	59	43	24	5	0
May	56.7	62.1	57.1	58.6	65.2	55.1	65.8	53.7	81	72	48	34	0	0
June	66.8	71.6	66.6	68.3	71.2	64.8	74.3	63.2	89	79	60	47	0	0
July	72.1	77.2	71.6	73.6	75.6	69.5	80.0	69.3	91	79	70	56	0	1
August	71.6	76.3	71.5	73.1	76.6	68.7	78.5	67.5	88	80	64	55	0	0
September	65.8	71.3	66.7	67.9	74.5	63.8	75.3	64.6	87	75	55	42	0	0
October	56.5	62.1	57.9	58.8	64.3	55.2	66.2	54.2	81	67	48	31	0	0
November	44.2	48.9	45.5	46.2	51.6	41.9	54.1	41.8	69	55	30	14	10	0
December	35.4	39.5	37.3	37.4	43.9	31.1	44.0	32.1	62	43	26	2	27	0
Spring	......	......	......	48.9	54.2	45.6	......	......	......	......	......	......	......	......
Summer	......	......	......	71.6	74.2	68.8	......	......	......	......	......	......	......	......
Autumn	......	......	......	57.6	62.9	54.2	......	......	......	......	......	......	......	......
Winter	......	......	......	35.7	42.9	31.3	......	......	......	......	......	......	......	......
Year	......	......	......	53.5	56.0	50.2	......	......	......	......	......	......	......	......

	J	K	N	O	R	S
	Range of temperature for period.	Mean relative humidity.	Average number of fair and clear days.	Average rainfall in inches.	Prevailing direction of wind.	Average velocity of wind, in miles, per hour.
				Inches.	From	Miles.
January	57	78.2	20.0	4.22	N. W.	14.3
February	57	76.7	18.2	3.60	N. W.	16.1
March	56	74.9	19.2	5.14	N. W.	16.4
April	54	74.2	19.5	3.34	N. W.	14.6
May	47	76.7	23.2	2.62	S.	12.5
June	42	79.5	22.1	3.81	S.	10.8
July	35	79.7	23.7	3.30	S.	10.0
August	33	80.3	21.5	5.77	S.	9.8
September	45	76.8	21.4	4.46	E.	11.7
October	50	75.1	22.7	3.53	N. W.	13.6
November	55	72.5	18.3	3.73	N. W.	15.7
December	60	75.7	18.9	4.15	N. W.	15.9
Spring	72	75.3	61.9	11.10	N. W.	14.5
Summer	44	79.8	67.3	12.88	S.	10.2
Autumn	73	74.8	62.4	11.72	N. W.	13.7
Winter	61	76.9	57.1	11.97	N. W.	15.4
Year	90	76.7	248.7	47.67	N. W.	13.4

To illustrate more perfectly the *equability* of the temperature at Cape May and the advantages possessed by its climate in this respect as compared not only with those of New York City, Philadelphia, and Baltimore, but also with those of several of the New Jersey coast stations, the following tables, copied from Professor Smock's "Appendix," are here introduced.

"These figures give the *average* extremes for each month of the year; that is, they indicate the highest and lowest temperatures which we may expect every day in any given month. The second part of the table gives the recorded extremes. It shows us what temperatures may be possibly experienced at these several places in the several months; the upper one shows what are probable. The months stand at the head of the double columns. The first of each gives the average maximum, and the second the average minimum temperature. Since these observations were in each case taken by instruments of like pattern, and compared with standards, and were made under the general supervision of the United States Signal Service Office, and cover the same period of six years, the results are valuable and suggestive. A longer

Table showing the Average Highest Daily Temperatures and the Average Lowest Daily Temperatures by Months.—Period, 1875–1880, *Six Years.*

	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
New York City, N. Y.	38	23	40	24	45	31	56	40	69	52	77	61	82	67	80	65	73	58	63	47	49	37	39	26
Sandy Hook, N. J.	37	25	39	26	44	31	54	41	69	52	77	62	82	68	79	67	71	60	62	51	50	38	40	28
Barnegat, N. J.	39	24	39	25	44	31	54	39	65	50	73	58	79	64	79	65	71	59	64	48	49	36	40	27
Atlantic City, N. J.	40	25	40	25	46	31	54	39	65	50	74	59	79	65	79	66	72	59	63	48	50	36	41	27
Cape May, N. J.	41	29	41	30	47	35	54	43	66	53	74	63	79	69	79	69	72	63	65	52	52	41	43	32
Philadelphia, Pa.	40	25	41	26	48	32	59	42	70	53	79	63	84	69	81	67	73	57	65	48	50	38	40	27
Baltimore, Md.	42	28	43	30	51	34	61	44	73	55	82	65	86	71	82	67	75	59	65	49	52	38	43	29

Table showing the Extreme Temperatures by Months.—Period, 1875–1880, *Six Years.*

	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
New York City, N. Y.	64	−6	65	−1	72	8	81	21	94	34	95	47	99	59	90	55	94	42	88	31	73	7	62	−6
Sandy Hook, N. J.	61	−3	64	2	67	11	77	23	93	35	93	50	100	50	93	57	92	40	84	33	71	8	68	1
Barnegat, N. J.	61	−12	70	−1	73	10	79	19	91	34	93	47	96	53	93	55	90	41	82	28	73	11	63	−7
Atlantic City, N. J.	64	−3	71	−5	72	10	79	19	89	33	90	47	99	53	89	53	94	43	81	29	72	10	64	−7
Cape May, N. J.	58	1	59	2	69	13	76	24	81	37	89	47	90	56	88	57	87	42	81	33	72	14	61	2
Philadelphia, Pa.	67	−5	67	−1	75	9	81	20	96	35	95	49	100	60	93	55	91	43	87	31	77	8	65	−5
Baltimore, Md.	71	−1.5	67	−3	76	9	83	23.5	94	34	97	51	99	59	94	55	92	40	89	30	78	15	67	−3

period might change slightly some of the figures, but would not be likely to alter their relations nor affect any comparisons. It would be very desirable to have stations farther in the interior, and especially in our Highlands. In the absence of such, the daily records made in New York, Philadelphia, and Baltimore are substituted. New York City may represent the northeast part of our red sandstone plain, and Philadelphia our southern interior" (Professor Smock, op. cit., p. 41).

It is commonly stated that "figures cannot lie," and, however much this statement may be open to question in the case of climatological figures, as usually reported. nevertheless, when the authority for our figures is as good as it is in the present instance, and when the observations from which such figures are derived are sufficiently abundant in number (being both frequently repeated and extending over a considerable space of time), we may at least claim that, *for those who will have the patience to study them carefully,* such abundance of figures will insure a closer approach to truth than will any general statements or general and personal observations of travellers and visitors. This, therefore, shall be our excuse in the present instance for introducing, together with further interesting remarks concerning the climate of Cape May, two other tables illustrating the comparative mildness of its winter climate and its great equability of temperature as compared with a number of other noted winter resorts of the United States. The passage about to be quoted and the contained tables are taken verbatim from another climatological contribution of the author mentioned above, Professor Smock, which contribution is entitled "Cape May as a Winter Resort," and constitutes the latter portion of the little pamphlet entitled "Cape May as a Health Resort."

"The records of temperature kept at Cape May indicate an absence of extremes and a more equable climate than any other at this latitude in our country. The average temperature of the three winter months is 36° F.; that of the spring is 48.8° F. The winter isothermal of 36° runs through West Virginia, North Carolina, and across Northern Georgia, or near the parallels of 36 and 37 degrees north latitude. The ameliorating influence of the sea is therefore equivalent to a removal of three degrees southward. As compared with Atlantic City the winter at Cape May is 2.1° warmer, and it is 3.5° warmer than the same season at Philadelphia. But the mildness of the winter is shown more strikingly when the minima or lowest winter temperatures are examined.

"First, there are no records of any readings below zero. During the cold wave of December, 1880, which swept over all the Eastern United States, and extremely low temperatures were observed far southward, the minimum at Cape May was two degrees *above zero.* The mildness of the winters is appreciated by the farmers in this county, who leave their cattle on the island beaches which fringe the ocean, to seek their own food and shelter during the winter months. Ice of sufficient thickness to be gathered is not obtained every winter. The snowfall is light and sleighing is rarely possible. The flora has a more southern character, and this county is the northern limit of several species of plants. The very beautiful evergreen shrub, known commonly as the Chinese Box, and botanically as Euonymus Japonica, thrives and ornaments many gardens and private grounds. It is not hardy except in the Southern States. But the highest and lowest thermometrical readings are of more significance; and in a study of climate these daily extremes are always the most important factors. They give us the changes. . . . For comparison with other well-known localities the following tables are here given. In the first one of them the average highest daily temperature, the average lowest daily temperature, and the average daily range are exhibited for six months, viz.: October to March inclusive. The second table gives the extreme temperatures and the greatest daily ranges for the same months The places selected are stations of the United States Signal Office. As their observations were made with standard instruments they are the best which can be had for such comparisons. The South Atlantic States are represented by Augusta, Ga., and Jacksonville, Fla. Key West is on the Gulf Coast, and noted for its mild and equable temperatures. The San Antonio record stands for the dry and salubrious interior of Texas. San Diego is a noted health resort in Southern California. The period covered by the tables is, for the New Jersey stations, six years, 1875–1880 inclusive. The Augusta and Jacksonville series are for five years; the Key West record extends over seven winters; the San Antonio over four, and that of San Diego over five seasons.

Table of Mean Temperatures.

	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Average highest.	Average lowest.	Average daily range.	Average highest.	Average lowest.	Average daily range.	Average highest.	Average lowest.	Average daily range.	Average highest.	Average lowest.	Average daily range.	Average highest.	Average lowest.	Average daily range.	Average highest.	Average lowest.	Average daily range.
Atlantic City, N. J.	63	48	15	50	36	14	41	27	14	40	25	15	40	25	15	46	31	15
Cape May, N. J.	65	52	13	52	41	11	43	32	11	41	29	12	41	30	11	47	35	12
Augusta, Ga.	71	51	20	64	45	19	55	38	17	57	39	18	58	39	19	68	47	21
Jacksonville, Fla.	77	60	17	71	54	17	65	46	19	65	46	19	66	47	19	74	54	20
Key West, Fla.	83	74	9	79	70	9	74	66	8	75	65	10	77	67	10	79	68	11
San Antonio, Tex.	81	59	22	69	46	23	60	42	18	61	42	19	68	50	18	77	56	21
San Diego, Cal.	72	57	15	67	51	16	64	47	17	61	46	15	63	49	14	64	50	14

Table of Extreme Temperatures by Months.

	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Maximum.	Minimum.	Greatest daily range.	Maximum.	Minimum.	Greatest daily range.	Maximum.	Minimum.	Greatest daily range.	Maximum.	Minimum.	Greatest daily range.	Maximum.	Minimum.	Greatest daily range.	Maximum.	Minimum.	Greatest daily range.
Atlantic City, N. J.	81	29	28	72	10	27	64	−7	36	64	−3	39	71	−5	33	72	10	28
Cape May, N. J.	81	33	25	72	14	23	61	2	33	58	1	29	59	2	28	69	13	26
Augusta, Ga.	86	34	34	81	26	35	77	20	37	79	17	36	78	22	35	85	25	38
Jacksonville, Fla.	86	43	34	84	36	32	81	24	37	80	25	33	83	32	33	87	31	32
Key West Fla.	92	65	20	91	52	19	88	44	20	90	49	21	87	55	18	89	53	18
San Antonio, Tex.	99	37	37	87	22	40	86	18	41	81	16	43	88	29	43	92	31	35
San Diego, Cal.	90	44	31	79	23	40	82	35	32	78	35	32	77	38	25	95	39	43
Newport, R. I.	79	22	..	66	8	..	62	6	..	58	−13	..	58	−15	..	64	−6	..
Fortress Monroe, Va.	89	30	..	82	15	..	69	17	..	72	2	..	72	4	..	78	13	..

Atlantic City, 1875–1880 inclusive; Cape May, 1875–1880 inclusive; Augusta, 1874–1879 inclusive; Jacksonville, 1874–1879 inclusive; Key West, 1872–1879 inclusive; San Antonio, 1872–1875 and 1877–1879 inclusive; San Diego, 1874–1879 inclusive.

"The first table shows the slight daily range of temperature at Cape May. As compared with Key West it

is three to four degrees greater in autumn and early winter, in February and March the difference is *one degree* only in favor of Key West; or, in other words, the *daily variation is, on the average, very little more at Cape May than at Key West.* Of course it is colder, as appears in the column of average lowest temperature. When we come north and take Augusta, Ga., into comparison, we note that the average lowest temperature, day by day, at Augusta is, in autumn, only from one to four degrees higher than it is at Cape May; in winter and in March the difference increases to ten and twelve degrees in favor of Augusta, but the daily range at the latter place is much greater. That Cape May is more equable than either of the other stations is also apparent. The second table contains two additional stations, Newport and Fortress Monroe. They have been added as both of them are spoken of as remarkably mild and equable. The much wider range and the greater extremes of both of them are apparent at once, when compared with Cape May. Fortress Monroe is quite as cold, and Newport shows minima readings varying from three to seventeen degrees lower. Examining the second table we observe that the greatest daily ranges recorded at Cape May have varied from twenty-three degrees in November to thirty-three degrees in December, whereas at all the other stations, excepting Key West, this maximum daily range exceeds thirty-seven degrees, and at San Diego amounts to forty-three degrees. The extremes at Key West are from eighteen to twenty-one degrees. The greater evenness of temperature at Cape May is remarkable when it is thus compared with all these more southern localities, excepting Key West. Again, in the extreme low temperatures its mildness is apparent, as compared with Atlantic City, being from two to nine degrees warmer. The maximum temperature does not get so high as at the last-named place. During the autumn the lowest readings at Augusta, San Antonio, and San Diego are quite as low as they are at Cape May, but in the winter these places are warmer by ten to thirty degrees. Key West and Jacksonville are still warmer. The greatest daily range at these southern stations is due to much higher temperatures or to hot waves, and not so much to sharp depressions of the mercury. The oscillations are greater, but at higher temperatures than at Cape May. The latter is more steady and colder. It is, however, the sudden and great changes which enervate and prostrate the invalid. The sharp frosts and cold waves sweep over the continent and reach to the Gulf, and are evident in sudden changes of temperature everywhere excepting in localities, as Cape May, where the ameliorating influences of the sea modify them. As stated above, the hot waves are still more marked in intensity at the South."

In the latter of the two tables quoted above the length of the period of observations from which the Newport and Fortress Monroe figures are taken is not stated. The maximum and minimum figures of this table are identical in character with those standing respectively in the left hand subdivision of column "E," and in the right hand subdivision of column "F," of the large climate charts accompanying many of the articles in this HANDBOOK. Such charts are to be found in this work for all of the nine places mentioned in the table, with the single exception of Fortress Monroe; and as the period of observations upon which these figures are based is, with the exception of San Antonio, longer than the period comprised in the table, such charts will give a somewhat more accurate picture of the possible extremes of temperature liable to occur at the places in question than can be derived from this table. For figures showing the *greatest daily range* known to have occurred at each station, Professor Smock's table alone can be appealed to by the writer, as such figures neither appear among, nor are deducible from those of his own charts.

A chart giving the extremes of temperature for eight of the stations specified in Professor Smock's table, and for Norfolk, Va. (as a substitute for the more distinctively maritime, though neighboring station, of Fortress Monroe), is herewith appended, its figures having been taken from the large climate charts above referred to.

Table of Extreme Temperatures, Deduced from Signal Office Charts.

Name of station.	Latitude N.	Longitude W.	Height of place of observation above sea level.	October.		November.		December.		January.		February.		March.		Period of observations.	
				Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Begins	Ends
Atlantic City, N. J....	39°22	74°25'	13 feet.	83.0	29.0	72.0	10.0	64.0	−7.0	64.0	−3.0	71.0	−5.0	72.0	10.0	Jan. 1, 1874	Dec., 1883
Cape May, N. J........	38°56'	74°58'	27 "	81.0	31.0	69.0	14.0	62.0	2.0	58.0	1.0	59.0	2.0	65.0	9.0	June 1, 1871	Dec., 1883
Augusta, Ga.........	33°28'	81°54'	167 "	92.0	29.0	84.0	24.0	77.0	7.0	79.0	15.0	82.0	22.0	89.3	22.0	Jan. 1, 1872	Dec. 31, 1883
Jacksonville, Fla......	30°20'	81°39'	5 "	92.0	40.0	84.0	30.0	81.0	19.0	80.0	24.0	83.0	32.0	88.0	31.0	Oct. 1, 1871	Dec. 31, 1883
Key West, Fla........	24°34'	81°49'	6 "	92.0	65.0	91.0	52.0	88.0	44.0	90.0	48.0	87.0	55.0	89.0	53.0	Nov. 1, 1870	Dec. 31, 1883
San Antonio, Tex.....	29°28'	98°22'	656 "	99.0	41.0	88.0	21.0	82.0	10.0	80.0	14.0	88.0	17.0	92.0	27.0	Mar. 1, 1877	June 1, 1883
San Diego, Cal........	32°43'	117°10'	49 "	92.0	44.0	85.0	38.0	82.0	32.0	78.0	32.0	82.0	35.0	99.0	38.0	Nov. 1, 1871	Dec. 31, 1883
Newport, R. I.........	41°29'	71°19'	14 "	81.5	30.0	71.2	4.0	60.0	−3.0	61.5	−7.8	56.0	−2.0	63.0	8.9	Aug. 1, 1875	Mar. 31, 1883
Norfolk, Va...........	36°51'	76°17'	13 "	89.0	31.0	80.0	20.0	73.0	6.0	80.0	8.0	81.0	9.0	81.0	16.0	Jan. 1, 1871	Dec. 31, 1883

This chart, like Professor Smock's table, serves to demonstrate the comparative absence of extreme temperatures at Cape May, but indicates a less difference in this respect between the climate of Cape May and that of Newport than we find from the figures of his table. What has already been said in the article on Atlantic City, respecting the modifying influence upon the climate of the southern portion of the Atlantic coast of New Jersey exerted by the Gulf Stream, applies with equal force to the climate of Cape May. The relative humidity of Cape May, as shown by the figures of the Signal Office chart, is less than that of Atlantic City, but a possible source of error in this matter has already been referred to in the Atlantic City article.

The rainfall of Cape May is rather greater than that of Atlantic City (15.7 per cent. greater). As already mentioned (Atlantic City article), Cape May is a much more windy station than is Atlantic City; indeed, it is one of the most windy of all the United States Signal Service stations. This great windiness is the chief blemish in the climate of the place. The therapeutic advantages of a winter residence at Cape May are similar to those derivable from a sojourn at Atlantic City during the same season, and the former resort is but little farther distant from the great cities of New York and Philadelphia than is the latter place. In a straight line the distance of Cape May from New York City is about one hundred and thirty-five miles in a south-southwest direction, and from Philadelphia it is distant about forty-five miles in a south-southeast direction. The hotel accommodations of Cape May are abundant and noted for their excellence. The daily arrivals of visitors during the height of the summer season are estimated by the thousand. The bathing facilities are unsurpassed, the beach being remarkably fine and composed of sand so firmly compacted and so hard as to admit of easy driving upon the very shore itself.

Huntington Richards.

CAPON SPRINGS. *Location and Post-office,* Capon Springs, Hampshire County, W. Va.

ACCESS.—Go to Capon Station on the Harper's Ferry & Valley Branch of the Baltimore & Ohio Railroad, fifty miles west of Harper's Ferry. Situated in a wild and mountainous region, the thermometer rarely rising above 75° F. in summer, the air being cool and dry, these springs offer unusual attractions, aside from the medicinal virtues of the waters. There are several springs, including a good chalybeate and a good sulphur spring. The two principal fountains are known as the Main and the Beauty Spring, and have the following composition:

ANALYSIS.—One pint contains:

	Main Spring (J. W. Mallet).	Beauty Spring (J. W. Mallet).
SOLIDS.	Grain.	Grain.
Carbonate of soda	0.074	0.079
Carbonate of magnesia	0.180	0.158
Carbonate of iron	0.005	0.006
Carbonate of manganese	trace	trace
Carbonate of lime	1.041	1.044
Carbonate of lithia	trace	trace
Carbonate of copper	....	trace
Chloride of sodium	0.007	0.006
Sulphate of potassa	0.021	0.020
Sulphate of lime	0.074	0.051
Sulphate of strontium	trace	trace
Phosphate of lime	trace	trace
Fluoride or calcium	trace	trace
Alumina	0.002	0.002
Silica	0.088	0.084
Nitrates	trace	trace
Organic matter	0.025	0.023
	1.517	1.473
GASES.	Cub. in.	Cub. in.
Carbonic acid	1.07	0.91
Oxygen	0.22	0.27
Nitrogen	0.46	0.46

In addition to the dissolved gases noted above, there is a free escape of gas from the surface of the water of Main Spring, estimated by Professor Mallet to be from 300 to 350 cubic inches per hour, consisting of

	Parts.
Nitrogen	78.74
Oxygen	9.02
Carbonic acid	4.38
Marsh gas	7.86
Total	100.00

Temperature of the water is 65.5° F. (Walton).

THERAPEUTIC PROPERTIES.—The Main and Beauty Springs are alkaline carbonated waters with a trace of lithia, and are useful in disorders of digestion, catarrhal affections, rheumatism, and gout. The effect of bathing in the waters is to clear the skin of many vesicular, squamous, and papular eruptions; and the application of the water, or of the moss which grows in it, is very efficacious in curing the very annoying inflammation resulting from the "poison oak."

The hotel is a very extensive establishment, 450 by 40 feet, five stories high, and the surrounding grounds are laid out with a view to the entertainment of the guests. The bath-houses face the hotel, and are provided with hot, cold, plunge, douche, and shower baths. The revenue from the baths, by a law of the State, is expended in maintaining and improving the place.

The geological deposits about the springs consist of sandstone, on edge. The mean temperature of the year is about 46° F. The rainfall is about forty inches.

George B. Fowler.

CARAWAY (*Carum*, U. S. Ph.; *Carui Fructus*, Br. Ph.; *Fructus Carvi*, Ph. G.; *Carvi*, Codex Med.). The fruit, usually called the seed, of *Carum Carvi* Linn., Order *Umbelliferæ*. It is a biennial herb, with a long, brown, tapering, edible root, a slender, erect, branching, hollow stem, and bi- or tri-pinnate leaves, with narrow linear segments. Flowers minute, in numerous compound umbels, with scanty involucres, and the peculiar construction characteristic of the order, viz.: calyx and corolla superior, pentamerous; stamens alternate; ovary inferior, two-celled, two-seeded, ripening into two lightly adherent achenia (technically called mericarps). It is a native of Northern and Central Europe, Iceland, and Siberia, and besides is cultivated and naturalized in nearly all temperate countries. The dried fruits, usually separated into their respective mericarps, are from three to five millimetres long ($\frac{1}{5}$ inch), slender, slightly curved, tapering at each end, and marked with five fine yellow ribs, alternating with dark-brown intervening spaces. There is one large oil-tube between every two adjoining external ribs, and two between every two adjoining ventral ones, six in all. They have an agreeable aromatic odor, and a mildly spicy taste, which are familiar to every one.

FIG. 558.—Caraway Fruit. Enlarged about four times. (Baillon.)

Caraway yields from three to five per cent. of an agreeable, colorless or light-yellow *essential oil*, of penetrating odor and pungent taste—sp. gr. 0.92 to 0.975 (*Oleum Cari*, U. S. Ph.). It is a composite oil, and may be separated into a heavier portion, *carvol*, and a lighter terpene, *carvene*. The fruits contain some *fat* (from the seeds), which has no medical significance, and inert vegetable material.

USES.—Caraway is chiefly employed for domestic purposes, as a favorite flavor and perfume. It is also used in various cordials, like the German "*Kümmel.*" In medicine its qualities and uses are exactly the same as those of Anise. It is one of the ingredients of the officinal substitute for gin (*Spiritus Juniperi Compositus*, U. S. Ph.), which contains one part of the oil in three thousand. There is no other officinal preparation.

Dose, of the seeds, an infusion made with from five to fifteen grams (5 to 15 Gm. = ʒ j. ad iv.); of the oil, from five to fifteen drops.

ALLIED PLANTS.—The genus *Carum* is a large one, including fifty species and containing a number of useful aromatics. *Carum Ajowan* B. and H. (Ammi officinal Codex Med.), with smaller fruits, takes the place of Caraway in India and the East. Its oil, like that of Caraway, is separable into a lighter and a heavier portion, *cuminol* and *cymol*. For the order *Umbelliferæ*, see ANISE.

ALLIED DRUGS.—All the milder essential oils and the products that furnish them. See ANISE; also PEPPERMINT.

W. P. Bolles.

CARBOLIC ACID, *Phenic Acid, Phenylic Alcohol, Phenol*: C_6H_5OH. This important substance, though commonly called an acid is, properly, not such, but a member of the group of *phenols*, bodies regarded as derivates of hydrocarbons of the benzene series by the replacement of one or of more atoms of hydrogen of the principal chain by hydroxyl (OH). In carbolic acid a single hydrogen atom of benzene itself is so replaced, so that this derivate is the simplest possible phenol in point of chemical constitution. Being also the best known member of the group it is chemically entitled *phenol*, simply. Carbolic acid is an ingredient of coal-tar, and is obtained therefrom. The tar abounds in phenols, and by fractional distillation and certain special manipulations, carbolic acid is separable from the other constituents in varying degrees of purity. In the markets may be found pure carbolic acid, crystalline at ordinary temperatures, and impure acids of different grades, the best crystalline, but the others fluid. These impure acids consist of carbolic acid (phenol) and the closely related phenol "cresylic acid" (cresol), and other phenols in admixture. The lower grades, indeed, may contain but little carbolic acid, but are yet efficient, since the other phenols of coal-tar possess similar properties to carbolic acid. These impure carbolic acids are often sold under the name of *coal-tar creasote*, and are graded "No. 1" and "No. 2," according to purity. The United States Pharmacopœia recognizes as officinal pure carbolic acid, and an impure article corresponding to the "No. 1" of the fluid impure acids of commerce.

Acidum Carbolicum, Carbolic Acid (U. S. Ph.). By this title is designated the pure article, described as follows: "A product of the distillation of coal-tar between the temperatures of 180° and 190° C. (356° and 374° F.). Colorless, interlaced, needle-shaped crystals, sometimes acquiring a pinkish tint, deliquescent on exposure, having a distinctive, slightly aromatic odor resembling creasote; when diluted, a sweetish taste, with a slightly burning after-taste, and a neutral reaction. It produces a benumbing, blanching, and caustic effect on the skin. Carbolic acid is soluble in twenty parts of water at 15° C. (59° F.); one hundred parts of the crystals are liquefied by the addition of about five parts of water; this liquid is rendered turbid by the further addition of water, until two thousand parts have been added, when a stable and clear solution is formed. It is very soluble in alcohol, ether, chloroform, benzol, disulphide of carbon,

commercial and absolute glycerin, and fixed and volatile oils. The crystals melt at 36° to 42° C. (96.8° to 107.6° F.), and boil at 181° to 186° C. (357.8° to 366.8° F.), the higher melting and the lower boiling-points being those of the pure and anhydrous acid. On continued heating, the acid is completely volatilized. Carbolic acid coagulates albumen or collodion (difference from creasote)" (U. S. Ph.). As regards the color of carbolic acid, the tendency to acquire a pink tinge is the stronger the purer and more anhydrous the sample (Squibb). Good specimens, therefore, unless recently made, are more likely than not to be of pinkish hue. The odor, stated in the above-quoted pharmacopœial description to be one "resembling creasote," would be better described as "reminding of creasote," for the smell of the two substances, though of a certain generic quality, so to speak, is yet distinctly different in the two instances, so much so that Squibb states that the absence of a proper creasote odor may be accepted as good practical proof of the purity of a sample of carbolic acid. The proper carbolic-acid odor is much less rank and disagreeable than that of other associated phenols, a fact that, apart from other considerations, constitutes a good reason for selecting a chemically pure carbolic acid for surgical use. The reaction between carbolic acid and water is peculiar. On adding water to carbolic acid in small measures, the crystals first liquefy by the solution of the water, forming a transparent fluid. The proportion of water thus soluble in carbolic acid seems to be variable. The pharmacopœial description sets the limit at "about five parts" to the hundred of acid, but Squibb finds that while this may be true of the mixture of different phenols formerly passing under the name of carbolic acid, it is not true of good samples of genuine carbolic acid itself, such samples dissolving as much as thirty-five per cent., even, of water. These saturated carbolic-acid solutions of water are, as stated, fluid, and are themselves soluble in additional water only to a limited extent—five per cent. according to the United States Pharmacopœia, six per cent. according to Squibb. As regards the melting and boiling points, Squibb points out that these are affected by the amount of water that a sample may contain, and that perfectly anhydrous commercial samples are rare, from two to four per cent. of water being almost always present. According to his determinations the congealing and boiling points given in the Pharmacopœia are too high, three "market specimens, all of excellent quality," having been found to congeal, respectively, at 29.4° C. (85° F.), 36.8° C. (98° F.), and 38.5° C. (101° F.), and the first and last of these to boil, respectively, at 173° C. (343.4° F.), and 170° C. (338° F.). The congealing-point is so readily further reduced by a small addition of water, such as may easily occur through spontaneous deliquescence in a stock bottle frequently opened, that a sample permanently fluid at ordinary temperatures is not therefore to be regarded as in any way inferior. So small an addition as that of three per cent. of water to a good commercial sample may be enough to determine permanent fluidity.

Acidum Carbolicum Crudum, Crude Carbolic Acid (U. S. Ph.). This article is a distillate of *dead-oil*, itself a distillate of coal-tar taken between certain temperatures (165° to 190° C.). It corresponds to what was officinal in the former revision of the Pharmacopœia under the title *impure carbolic acid*, and to what is sold commercially as *impure carbolic acid, No.* 1, and must not be confounded with what is *commercially* known as *crude carbolic acid*. According to Squibb, the products of distillation of "dead-oil" are as follows: A first immediate distillate, which is the crude carbolic acid of commerce; this, subjected to redistillation, yields, as secondary products, a first redistillate, highly charged with carbolic acid and the source of the purified article, and subsequently a second redistillate, coming over between the temperatures of 185° and 195° C., which redistillate, mixed with the "uncrystallizable drainings and residues" left over from the first after separation of the pure carbolic acid, constitutes the article under present consideration. It thus appears, as Squibb justly points out, that this officinally so-called *crude* acid is not such in the proper sense of the word, but is, as it used to be officinally, and still is commercially called, properly an *impure* acid. The article is thus officinally defined and described: "A liquid obtained during the distillation of coal-tar between the temperatures of 170° and 190° C. (338° and 374° F.), and containing carbolic and cresylic acids in variable proportions, together with other substances. A nearly colorless or reddish-brown liquid, of a strongly empyreumatic and disagreeable odor, having a benumbing, blanching, and caustic effect on the skin or mucous membrane, and a neutral reaction. Crude carbolic acid should not dissolve in less than fifteen parts of water at 15° C. (59° F.), nor should the solution have an alkaline reaction (absence of alkalies)" (U. S. Ph.). The tests just mentioned are important for the reason that the addition of an alkali to crude carbolic acid increases the latter's solubility in water, and hence a frequent adulteration is effected by watering the acid with the solvent assistance of an alkali. Crude carbolic acid is cheaper than the pure crystalline acid, equally, if not even more, efficient as a germicide and antiseptic, but is rank and offensive in odor—the odor in this case really resembling that of creasote—and is more irritant to animal tissues.

Besides the foregoing, other grades of so-called impure carbolic acid or coal-tar creasote are to be found in the markets, which are later redistillates from the commercial crude carbolic acid, obtained as the immediate product of distillation of dead-oil, as already described. These second grades of so-called impure carbolic acid consist mainly of cresylic acid (cresol), xylol, and other phenols of a higher boiling-point than carbolic acid, and contain none, indeed, of the latter substance, all the carbolic acid of the original crude substance having come over in the earlier distillations. These latter distillates, however, have similar germicidal and antiseptic powers to carbolic acid, and being cheap, may be used effectively for the purposes of carbolic acid elsewhere than directly upon living tissues. "Impure carbolic acid, No. 2," of commerce, is a fluid, soluble in water to the extent of from forty to sixty per cent. (Squibb).

The *effects* of carbolic acid and of the other phenols associated with it in coal-tar distillates are substantially identical, so that a single description will suffice. The effects of these substances which the physician needs to note may be divided into three categories for practical study, as follows: 1, Effects upon the vital endowments of bacteria and allied organisms; 2, Local effects upon the tissues of the human body; and 3, Constitutional effects upon the human system.

1. *Effects upon the Vital Endowments of Bacteria and Allied Organisms.*—By immersion in carbolic-acid solutions microbes may suffer temporary arrest or permanent loss of vital activity, the degree of the effect depending partly on the strength of the solution and partly on the vital tenacity of the particular organism, or even of the special stage of being of the organism under observation. To determine the exact toxic power of carbolic acid in this direction, an enormous number of experiments have been made, attacking the problem in a variety of ways. Of the more reliable of these experiments the results substantially agree, and these at the present writing justify the following broad statements: 1. Rod-forms of bacteria and allied organisms soaking in aqueous solution of carbolic acid tend to suffer arrest of vital activity when the strength of the solution reaches a point between one-fifth and one-half of one per cent., and to suffer death when the strength rises to one per cent. 2. Spore-forms, such as the spores of the anthrax bacillus, are much more tenacious of life, requiring for their certain killing a solution of from four to five per cent. strength, and a soakage of from two to three days' duration (Koch). 3. Aqueous solutions of carbolic acid are far more toxic to microbes than solutions in oil or alcohol (Koch). 4. Exposure to *vapor* of carbolic acid under the conditions obtaining in practical disinfection is practically without effect upon microbes or disease-germs, whether these be in rod-form or spore-form, and whether moist or dry.

2. *Local Effects upon the Tissues of the Human Body.*—Prudden[1] has observed under the microscope the effect

upon living leucocytes and ciliated cells of soakage in carbolic-acid solutions, with the following results: Under soakage in solutions ranging between one-thirty-second and one-fourth per cent. strengths, amœboid and ciliary movements slow or stop, but resume upon withdrawal of the carbolized fluid, and its replacement by a normal one. Under soakage in solutions of from one to five per cent. strength, however, the bodies under observation speedily lose, without possibility of resumption, their power of movement, and their protoplasm soon suffers disintegration. Applied to the human skin, comparatively weak solutions, such as the one and two per cent. solutions used in surgery, objectively cause a whitening and shrivelling of the cuticle, and subjectively a conjoint numbness and prickling sensation, followed, if the application be prolonged beyond a few minutes, by smarting. These painful sensations Squibb declares to be aggravated by elevating, and alleviated by depressing, the affected part —phenomena contrary to what usually obtain under circumstances of painful irritation. After withdrawal of the application the skin gradually resumes its normal appearance and tactile sensibility, recovery from the numbness, however, being slower than the return to natural appearance. Touched with the undiluted acid, the skin immediately whitens, while the circumjacent parts redden by irritation. Sharp pain, passing over into numbness, is experienced, the pain gradually subsiding after an hour's lapse, and the surface presenting the dry, scaly exudation so often seen on surgeons' hands in the days when operating under a carbolized spray was in vogue. The results of a continuous application of the pure acid are exemplified in a case reported, where, through a misunderstanding, a finger was wrapped in cloths soaked in undiluted carbolic acid, and kept so dressed through a night. The next morning the dressings were removed, and on the third day, when first seen by the reporter, the tissues of the finger were found black as jet, hard as wood, wrinkled and shrivelled, cold and absolutely anæsthetic, and with a pronounced line of demarcation between the unaffected and the mummified portion. Strange to say, however, under careful treatment the parts recovered.

3. *Constitutional Effects upon the Human System.*—Carbolic acid is very poisonous to all living things. In man, in mild poisoning, such as may follow slight absorption from carbolized dressings in surgical cases, the symptoms are restlessness and rise of temperature—symptoms easily mistaken for those of the very septic infection sought to be averted by the use of the acid; or in other cases occur headache, loss of appetite, languor, and cough, followed, if the poisoning continue, by persistent bronchial irritation, itching of the skin, dragging lumbar pains and a sense of heaviness, and want of power in the legs. In severer poisoning, such as may occur again from absorption from surgical dressings, or as will certainly result if any considerable quantity of carbolic acid be swallowed, the toxic action falls heavily upon the central nervous system. The sufferer rapidly passes into a condition of coma, with loss of reflex irritability, and with, occasionally, but exceptionally, convulsions (convulsions being, however, common in poisoning of the lower animals). The breathing is stertorous, the heart's action disordered—pulse at first unduly slow, afterward rapid, and, perhaps, intermittent, and the arterial pressure diminished. The skin is covered with sweat, the lips and hands are livid, and the whole aspect is that of great prostration. When the poisoning has occurred from swallowing the acid, supposing, as is commonly the case, that the same has been taken in concentrated condition, there are added to the above symptoms burning pain, extending from mouth to stomach, experienced at the moment of swallowing, and nausea and vomiting —symptoms due to the local action of the poison upon the mucous membrane of the alimentary canal. Carbolic-acid poisoning may result in death, which may begin either at the heart or lungs. In such cases the lesions, apart from the local effects where the strong acid has been swallowed, are not characteristic. There is a tendency to congestion of the great viscera; the blood may seem unduly dark and fluid, and there may be some fatty degeneration of the liver and kidneys, especially the latter, but yet none of these changes are invariable

Analysis of carbolic-acid poisoning in man and animals points to the following specific derangements as wrought by the agent: As regards the nervous system *coma* and *convulsions*—which latter phenomenon when it occurs is spinal in origin—and *modification of reflex activity*, at first by increase, and later by diminution and abolishment. As regards the *circulation*, while it is possible that in the beginning the heart-beats may be more powerful than normal, in the later stages of the poisoning the action is always feeble. Death is frequently by cardiac failure, and the heart is commonly found, post-mortem, in diastole, with flabby walls. Similarly the arterial pressure, which may be increased in the earlier stages of the poisoning, particularly if convulsions be present, notably sinks as the case progresses, apparently through paralysis of the vaso-motor centre. Upon *respiration* the action more commonly than not is opposite at the two extremes of the poisoning, the breathing at first being unnaturally rapid and shallow, while later it becomes slow, deep, and markedly stertorous. Duly devised experiments seem to show that these effects are due to a primary excitation of both the pneumogastric peripheries and centres followed by a secondary paralysis. *Body temperature*, in poisoning in the normal human subject, is variably affected, in some instances rising, in others falling, and in others remaining unchanged. When, however, carbolic acid is administered to a fevered subject, a considerable fall of temperature may occur, accompanied by sweating. In such case the loss of heat is probably independent of any effect in that direction wrought by the sweating, since a temperature-reduction has been observed in cases where all action of the sweat-glands was held in abeyance by duboisine (Raymond).

The fate of absorbed carbolic acid is obscure. Some of it is undoubtedly excreted, since it has been found by a number of observers in the urine, by Hoppe-Seyler in the saliva, and is believed by Lemaire to be present in the breath. Other portions are probably chemically transformed within the system. A result of excretion by the kidneys is to produce peculiar coloration of the urine, a fact furnishing a valuable clew to diagnosis in obscure cases of poisoning. The tint of the urine varies in different cases, in some being brownish, in others greenish black, and in others olive-green, turning a smoky black upon standing. Such urines may or may not have an adventitious odor, aromatic, or even distinctly that of carbolic acid. Exceptionably, furthermore, albumin, blood, or excess of urates may be present. These altered urines probably contain both carbolic acid under its own form and some product or products of its chemical transformation; but what these latter substances may be has not yet been satisfactorily determined.

The practically important points to the physician in the *toxicology* of carbolic acid are as follows: As a poison the agent is both swift and strong; death, and speedy death, being possible from absorption from wound-surfaces and even from the unbroken skin, as well as from ingestion. In cases of poisoning from swallowing, one of the most characteristic features, indeed, is the swiftness of march of the phenomena, a swiftness in which carbolic acid is outdone among the common poisons only by hydrocyanic acid. Thus in a recorded case where probably about an ounce of carbolic acid was swallowed, ten seconds saw the sufferer unconscious and three minutes found him dead. And almost always the symptoms begin within a few minutes, and death, if such be the issue, occurs within twelve hours. The symptoms have been already sufficiently detailed, it remaining in the present connection to note the pathognomonic points, which are the rapidly developed unconsciousness (in the common instance of the ingestion of a large quantity of strong acid), the stertorous breathing and feeble pulse—all coupled with the locally developed initial burning at the time of swallowing—vomiting, strong odor of carbolic acid in the breath, and peculiarly discolored, and possibly odorous, urine. The characteristic lesions, if, as is usual, the acid have been swallowed in concentrated condition, will also

be apparent in the mouth, fauces, and, upon autopsy, in the œsophagus and stomach, in the shape of a whitened, toughened, and corrugated condition of the mucous membrane. Or, in the stomach, the lining membrane may be chocolate-colored or blackened and sodden, and the gastric contents may be whitish, pinkish, or brownish in color. As regards a *fatal dose*, it may be said of the ordinary deliquesced acids of the shops that it will be a remarkable exception when two tablespoonfuls fail to kill, and that a single tablespoonful will be more likely than not to prove fatal. In children death has followed, several times, the taking of quantities much smaller. In the *treatment* of carbolic-acid poisoning, the first step is, of course, to save the system from further impregnation, by removal of the dressings, if it be a case of absorption from a wound-surface, or by evacuation of the stomach, if the poison have been taken by swallowing. For the latter purpose the stomach-pump should be used, emetics being likely to prove inoperative from the anæsthetized condition of the gastric mucous membrane. For antidote, saccharated lime was at one time in vogue, but at the present writing Baumann and Herter's suggestion of a soluble sulphate, such as sodic or magnesic sulphate, is undoubtedly the best. The theory is that the carbolic acid, even such of it as has already been absorbed, unites with the sulphuric acid of the sulphate to form the non-poisonous body *phenol-sulphonic* (sulphocarbolic) acid. Whether the theory be true or not, experiment has proved the alkaline sulphates to have a marked influence for good in carbolic-acid poisoning.

The *therapeutic applications* of carbolic acid are utilizations of its *antiseptic, disinfectant, anæsthetic,* and *antipyretic* powers. As regards the *antiseptic* use, it is to be noted that carbolic acid is decidedly inferior in antiseptic power to quite a number of available substances, and that for surgical employment it has the positively objectionable features of strong odor, disagreeable action upon the skin, and capability of absorption to the point of producing dangerous and even fatal constitutional poisoning. For surgical purposes aqueous solutions are commonly employed of strengths ranging from one to five per cent., the weaker for dressings to remain in contact with tissue, the stronger for occasional use or to disinfect hands, instruments, ligatures, etc. As a *disinfectant,* carbolic acid operates, of course, exclusively by its germicidal action, thus holding in abeyance or destroying, according to strength of application, the septic or infective activity that lives in certain living protoplasms. For certainty of disinfection, as has already been seen, actual soakage of the culprit germ in a carbolic solution of at least two per cent. strength is essential. Dainty sprinklings of carbolic lotions are therefore futile, and the hanging about a chamber of carbolized cloths with a view to aërial disinfection by the fumes therefrom, is but a noisome advertisement of ignorance or stupidity. Legitimately and thoroughly used, a two per cent. solution of carbolic acid is an efficient disinfectant, with the advantage of cheapness—the impure grades of the acid being for this purpose even more powerful than the pure—but with the ever-present disadvantage of a rank and even offensive odor. A solution of two per cent. strength does not injure textile fabrics. Carbolic acid has been given internally in the hope that the power which proves germicidal without the body will within the system oppose the career of so-called zymotic diseases. But theoretically, for this purpose, if we are to argue from the point of view of germicide action, the blood of the subject should be charged with at least one per cent. of carbolic acid, a condition involving a dosage overwhelmingly poisonous; and practically, the use of the remedy in the category of diseases referred to has been, so far, barren of important results. The *anæsthetic* action of carbolic acid is most strikingly utilizable for the relief of the pain of burns, for which purpose nothing is better than a one-half or one per cent. aqueous solution of carbolic acid applied on thin cloths—the cheap "crude" acid being here more effective than the pure (Squibb). Similar lotions may also palliate the itching and burning of skin disease or the irritation from catarrhs of mucous membranes. Thus in bronchitis the inhalation of the fumes of a bowl of boiling water charged with a few drops of carbolic acid may considerably allay pain and cough. So, again, irritability of the stomach may be quieted by this agent, and carbolic acid in small doses ranks among the standard means for arrest of vomiting. As an *antipyretic* carbolic acid is undoubtedly powerful, but its poisonousness will probably always defeat it in competition with such potent and at the same time innocent antipyretics as sodic salicylate and the cinchona alkaloids.

For *internal administration* the dose of carbolic acid should not exceed from one to four or five drops, and the daily allowance should not surpass 1.00 Gm (fifteen grains or minims). A convenient way of giving is to first dissolve in glycerin, in which menstruum carbolic acid dissolves in all proportions, and then dilute the necessary quantity of glycerin solution with water. Each dose of acid should be diluted to at least the volume of a tablespoonful for the taking.

For *external uses* aqueous solutions are most generally serviceable, as already so frequently seen. There is also officinal in the U. S. Pharmacopœia a preparation entitled *Unguentum Acidi Carbolici*, Ointment of Carbolic Acid, which consists of officinal "ointment" charged with ten per cent. of carbolic acid. *Edward Curtis.*

[1] American Journal of the Medical Sciences, January, 1881.

CARBON, OXIDES OF. There are two well-known oxides of carbon, viz., carbon monoxide and carbon dioxide, or carbonic anhydride. They are both invisible gases at ordinary temperatures and pressures; and are of interest to the physician from the fact that they are both irrespirable gases with which persons are frequently brought in contact, and which frequently produce poisonous and even fatal results. Carbon dioxide plays an important rôle in the physiology of the human organism. The names used to designate these compounds are somewhat variable and confusing, and, to avoid this uncertainty, we place all the names commonly met with at the head of the proper sections. Besides the above, C_4O_3 and C_5O_4 are known ("Enc. Brit.").

Carbon Monoxide, *Carbonous Oxide, Carbonic Oxide* (CO). This gas was discovered in 1799 by Priestley. It is always formed when carbon, or combustibles containing carbon, are burned with a limited supply of air. It does not occur free in nature except as the result of certain manufacturing processes. It is produced by the heating of coal with certain ores, such as those of iron and zinc. It is always prepared in an ordinary coal fire. The air entering through the grate produces at first CO_2, which, on coming in contact with the glowing coals above, is reduced to this lower oxide: $2CO_2 + C_2 = 4CO$.

This gas is the one which is frequently seen burning with a blue flickering flame at the surface of the coals in an open grate fire. The gas may be prepared for experimental purposes by passing carbon dioxide through an iron tube loosely filled with charcoal, heated to redness, or by heating in a flask a mixture of oxalic and sulphuric acids. In the last method the gas is mixed with an equal volume of CO_2, which may be absorbed by passing it through wash-bottles containing milk of lime.

Properties.—Carbon monoxide is a colorless, transparent, odorless, tasteless gas, which may be liquefied by a pressure of 35.5 atmospheres at −139° C. (282° F.), or at ordinary pressures and a temperature of −190° C. (374° F.).

The density of the gas is 14.(H = 1), and the specific gravity, 0.9678 (air = 1), or nearly that of air.

It is but slightly soluble in water or alcohol. It dissolves in hot caustic potash (KOH) solutions, with the formation of potassium formiate (KOCOH). It also unites directly with potassium, oxygen, and chlorine.

It dissolves readily in a solution of a cuprous salt in ammonium hydrate; consequently, ammonio-cuprous chloride is used to absorb it in the analysis of mixtures containing it.

It burns readily in air, with a blue non-luminous flame, the sole product of the combustion being carbon dioxide. At high temperatures it has a very strong affinity for oxygen, and will take it from many of the metallic ox-

ides. It is by its agency that iron ores are reduced to the metallic state in the blast furnace. The diffusive power of the gas is much greater than that of carbon dioxide, CO_2, and when red hot, cast-iron plates allow it to diffuse through them with comparative ease. In this way a small quantity of the gas finds its way into the air of rooms heated by stoves, and especially by ordinary hot-air furnaces.

Sources.—The most frequent sources of carbon monoxide, likely to produce it in poisonous or dangerous quantities, are open charcoal or stove coal-fires, defective stove-pipes or furnace flues, and illuminating gas, especially the variety known as *water-gas.*

A frequent cause of fatal poisoning is an open charcoal fire. This is sometimes used with suicidal intent, especially in some European countries. Leblanc gives the following analysis of the air of a confined space in which charcoal was burnt, and which proved rapidly fatal to a dog: Oxygen, 19.19 per cent.; nitrogen, 76.62 per cent.; carbon dioxide, 4.61 per cent.; carbon monoxide, 0.54 per cent.; marsh gas, 0.04 per cent.

In this case, however, the poisonous effects might not be due alone to the carbon monoxide, for 4.6 per cent. of carbon dioxide in an air containing 1.4 per cent. less oxygen than normal air, would form a poisonous atmosphere.

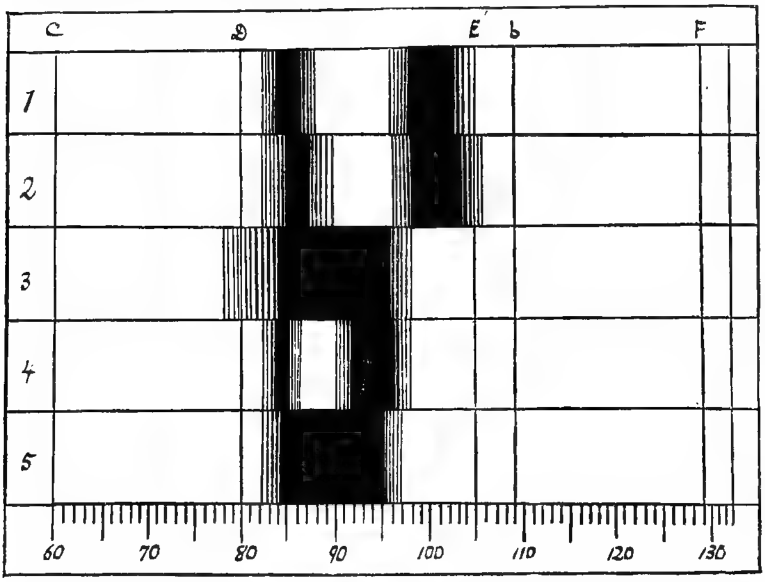


FIG. 559.—1, Absorption-bands of oxyhæmoglobin (Hoppe); 2, absorption-bands of CO_2 hæmoglobin, showing displacement of the bands (Hoppe). The same appearance is seen in the blood of persons poisoned by charcoal fumes or coal-gas. 3, absorption-band of reduced hæmoglobin, *i.e.*, it is No. 1, with a drop of ammonium sulphide added (Hoppe); 4 and 5, the same as Nos. 1 and 3, according to Hensen.

Another source of carbon monoxide, and one which is frequently overlooked, is from escape of the gas through defective flues, or even through the red-hot walls of the flues or pipes of stoves and hot-air furnaces. The gas thus finding its way into rooms frequently gives rise to headache, dizziness, loss of appetite, nausea, debility, and bronchial irritation, which last effect is sometimes very severe. Indeed, severe cases of capillary bronchitis in children have been traced to an escape of poisonous gases from a defective flue. The ordinary hot-air furnace, in common use at the present day, is the cause of a considerable and undetermined amount of suffering, and is on this account open to very serious objection. From ordinary stoves, where the draught is rendered imperfect by the downward direction of the pipe before entering the chimney, carbon monoxide and the other gases frequently escape into the room.

Perhaps the most frequent source of fatal quantities of this gas, especially in large cities, is the escape of illuminating gas. From thoughtlessly blowing out the gas, or accidentally turning the stop-cock, or having it turned by children, as occurred to a number of persons coming under the care of the writer, or from accidental breaking of pipes, the gas may find its way into a room in sufficient quantities to give fatal results. Even in waking hours, when the gas escapes slowly, the odor does not seem to be a perfect safeguard. (For a further discussion of this subject, see article on Coal Gas.)

PHYSIOLOGICAL ACTION.—Carbon monoxide is a very poisonous gas, entering the blood and combining with the hæmoglobin of the red corpuscles and expelling the oxygen. When the blood is pretty thoroughly saturated with this gas, death is usually, if not always, the result.

The blood of persons poisoned with this gas retains its bright red color for a long time after death, both in the body and out of it, and in the veins as well as in the arteries.

Properly diluted, the blood shows with the spectroscope two absorption-bands situated between the lines *D* and *E*, but slightly nearer *E* than the similar bands of oxyhæmoglobin (see Fig. 559).

These bands do not readily disappear when the blood is treated with ammonium sulphydrate, *i.e.*, the blood resists the action of reducing agents. In ordinary arterial blood, reducing agents change the spectrum, so that the two bands seen in 1 disappear, and one broad band, represented in 3, makes its appearance. Vogel has proposed to employ this peculiar behavior of hæmoglobin as a means of detecting CO in the air.

The process consists in shaking the mixture of gases with a drop of blood diluted with two or three cubic centimetres of distilled water, and observing the spectrum of this blood solution. This method is said to detect 2.5 to 4 parts per thousand, of this gas in the air, by its effect upon the blood.

Carbon monoxide blood, in the absence of oxygen, resists the action of putrefaction for a long time. The CO may be expelled from blood by allowing any inert gas to bubble through it, or by placing it in a vacuum. The very poisonous character of CO is explained by the behavior of the hæmoglobin of the blood toward it.

TOXICOLOGY.—The poisonous action of carbon monoxide has been known since 1802, when Guyton Morveau first observed it. Leblanc and Dumas' experiments show that air containing one per cent. of the gas will kill a dog in one and a half minutes. Dr. Letheby found that air containing 0.5 per cent. killed birds in three minutes. One per cent. of the gas in air renders it fatal to most animals, and 0.5 per cent. to some, even if the oxygen is normal or in excess of normal.

Symptoms.—The symptoms of carbonic-oxide poisoning are singularly persistent. The first subjective symptoms are dizziness, excruciating headache, debility, and a feeling of prostration; nausea and vomiting are not uncommon; convulsions are frequently seen in experiments upon lower animals, as well as in men poisoned by it. This gas seems to act as a narcotic poison, death usually occurring by coma. The face is usually, though not always, dusky and livid; pupils dilated. In man, when the quantity of gas is not sufficient to produce such pronounced results as those mentioned above, and when this small quantity is breathed for days or weeks, the symptoms are those of malaise, debility, anæmia, anorexia, and usually, headache. There is frequently a dry, irritative cough. These symptoms are sometimes mistaken for those of malaria, and probably are benefited by the tonic effect of quinine. When the severer symptoms are well

Carbon, Oxides of.

marked, the chances of recovery decrease with the length of time the patient has been exposed to the gas. When the time of exposure has exceeded eight hours, and coma has set in, the prognosis is very unfavorable. If the time is less than eight hours, and the coma is not too profound, there is reason to hope for recovery. This statement is based upon experiments upon the lower animals, and the histories of a number of recorded cases. Much will depend upon the amount of gas breathed ; but, other things being equal, the longer the blood is exposed to the gas, and the more thoroughly it becomes saturated, the more permanent is the injury, and the less chance there is for recovery. The characteristic *post-mortem appearances* are : the bright red color and persistent fluidity of the blood, and hyperæmia of the brain and meninges. The heart is usually nearly empty and flaccid.

The *treatment* of cases of poisoning by CO are, briefly, fresh air, cold affusions, stimulants, and artificial respiration where demanded. Even with all these, death will result in those cases in which the exposure has been of long duration, and the coma pronounced, *i.e.*, when the blood has become well-nigh saturated with the gas. In such cases transfusion, or displacing the poisonous with pure blood, or even with salt and water, seems more likely to succeed. Good results have followed this method of treatment in a number of cases.

CARBON DIOXIDE.—Also called *carbonic acid gas* and *carbonic anhydride.* (Fixed air, choke-damp.) Chemical formula, CO_2. Specific gravity (air = 1), 1.52 ; (hydrogen = 1), 22.

Sources.—When carbon is burned in oxygen, or with a free supply of air, this gas is formed ; hence it is a product of the combustion of all combustible bodies containing carbon. It is prepared in large quantities, by many manufacturing processes, from the combustion of coal. The burning of lime-kilns send large volumes of this gas into the air, partly from the fire and partly from decomposition of the limestone ($CaCO_3$) into *lime* and CO_2. Respiration is another source of the gas, and the expired air may accumulate in a tight room to such an extent as to become poisonous, and death may and has resulted. An adult man exhales about 0.7 cubic foot (20 litres) of CO_2 per hour, or 18 cubic feet (499 litres) per day. Another source of carbon dioxide is the alcoholic fermentation of saccharine fluids. This source is usually limited to certain kinds of industries, such as beer, wine, alcohol, and whiskey manufactories. In badly ventilated rooms, deaths have often occurred in the fermenting vats, from the accumulation of this gas. The subterranean heat of volcanic regions causes the decomposition of limestone as above mentioned, giving off CO_2, which either escapes through crevices, or accumulates in underground caverns, under pressure, and finally becomes absorbed by the water, and comes to the surface in the form of effervescing spring-water, like the well-known Saratoga Springs. The gradual oxidation of vegetable matters, either upon the surface of the soil or buried in it, generates a considerable quantity of carbon dioxide. The gas from these various sources may filter through the soil, crevices in the rock, or coal-bed, and accumulate in mines, wells, cellars, etc., in such quantities that the miners are unable to work in it. It is called by them *choke-damp*, to distinguish it from *fire-damp.* It is produced in mines by an explosion of marsh-gas (fire-damp), so that if the explosion does not kill persons unfortunate enough to be in the mine at the time, they may die from breathing the CO_2 developed by the explosion. The atmosphere, as will be seen, is continually receiving this gas in abundance from the above sources ; hence, out-door air always contains about 0.4 part per 1,000. The air of rooms and closed places frequently contains a much larger proportion than this. A well-ventilated room should contain not more than 0.6 part per 1,000 ; but owing to poor ventilation it frequently rises as high as 4 parts per 1,000 or more. Even in the open air, the amount depends somewhat upon the state of the weather, season of the year, etc. In still, foggy weather in large cities, the amount present in out-door air may rise as high as 0.8 part per 1,000, or enough to give the air a peculiarly suffocating effect upon those who breathe it.

Properties and Preparation.—It is a colorless, transparent, odorless gas, about one and a half times heavier than air, and may be poured from one vessel into another like water. It has a faintly acid taste. At ordinary temperatures it is soluble in its own volume of water, with which it probably enters into combination to form carbonic acid : $CO_2 + H_2O = H_2CO_3$. By increasing the pressure, water will absorb a very large amount of the gas, a large portion of which escapes again when the pressure is removed. The so-called *plain soda* is a strong solution of carbonic acid (H_2CO_3) in water, made under pressure. The gas may be expelled by heat, by freezing, or by removing the pressure. Under a pressure of fifty atmospheres at 15° C. (59° F.), it is condensed to a transparent, colorless, mobile liquid, not miscible with water or fixed oils, but readily so with ether, alcohol, naphtha, turpentine, and carbon disulphide. When the pressure is removed from the liquid, it evaporates with great rapidity, freezing a portion of itself into a snow-like solid, by the heat absorbed in the evaporation. The solid evaporates very slowly, and may be kept longer than the liquid. By moistening this solid with ether, and placing it under the bell of an air-pump, a temperature of −110° C. (−166° F.) may be obtained. Carbon dioxide is soluble in about one-third its own volume of alcohol at the ordinary temperature and pressure. Dry carbonic dioxide has no effect upon litmus-paper ; but if the latter be first moistened it is reddened, but on drying, the blue color is restored. Lime-water is at first rendered turbid by CO_2, owing to the precipitation of calcium carbonate ; but on conducting the gas into the turbid liquid for some minutes, the precipitate is redissolved, and the solution becomes clear again, owing to the formation of calcium bicarbonate ($H_2Ca(CO_3)_2$). This process frequently takes place in natural waters to produce *temporary hardness*, so called, because the calcium, and, at times, magnesium carbonate, thus held in solution, is precipitated by boiling off the excess of carbon dioxide. Solutions of caustic soda, potash, lime, baryta, etc., rapidly absorb CO_2 with the formation of carbonates of the metals. Such solutions are used to dissolve the gas from mixtures containing it. The gas does not support either respiration or combustion, although this property is not peculiar to carbon dioxide. It is not combustible. Sodium, potassium, phosphorus, boron, carbon, iron, zinc, and magnesia, at high temperatures, decompose it by removing its oxygen and converting it into either carbon monoxide or carbon. It is also decomposed by the chlorophyl of plants under the influence of sunlight and moisture, the carbon combining directly with the water to form soluble carbo-hydrates, and the oxygen escaping in the free condition. Carbon dioxide is usually prepared in the laboratory by treating a carbonate, usually calcium carbonate or marble, with a dilute mineral acid : $CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$.

Uses.—The following are among the most important uses of carbon dioxide : Notably, in the manufacture of carbonates and bicarbonates, carbonated waters, white lead, the decomposition of sucrate of lime in the preparation of sugar from beets, in setting free the hypochlorites from chloride of lime, in bleaching, and in giving a *bead* to beer, ale, wine, etc.

Carbonic acid (H_2CO_3) exists only in solution. It has not yet been isolated. When an attempt is made to concentrate it, the acid breaks up into water and carbonic anhydride (CO_2), which escapes with effervescence. The salts of the acid, the carbonates and acid carbonates (bicarbonates) are well known. Carbonic acid is a feeble acid, and is expelled from its combinations by most strong acids. The carbonates all effervesce when treated with the mineral acids, and this serves as a ready test. Some of the metals are dissolved by this acid, but with great slowness. Copper and lead are corroded by it, and hence these metals may contaminate "soda-water," beer, etc., drawn through pipes composed of these metals.

Physiological Action.—The physiological effects of carbon dioxide vary with the state of dilution or admixture

with air. *When pure* it causes almost instant death, if inhaled, from spasm of the glottis and *apnœa.* Even when somewhat diluted, there is almost immediate insensibility and loss of muscular power, and the person drops as if felled by a blow, and usually dies without a struggle, unless immediately removed into pure air. Such accidents are most likely to occur from going into deep wells, caves, mines, etc., where the gas, termed *choke-damp* by miners and well-diggers, has accumulated; or from putting the head into a fermenting vat which has been closed for a time; or from venturing too near to the mouth of a lime-kiln, burning buildings, or volcanoes.

When more largely diluted, or, as is most likely to occur, when the air is gradually poisoned by it, the first feeling is a sense of closeness, then weight or fulness in the head, pressure in the temples, giddiness, singing in the ears, somnolency, sometimes nausea and loss of muscular power. Death is preceded by coma, with stertorous breathing, rarely vomiting and convulsions; the face is usually of a leaden hue, or pale, and the heart's action, at first violent, finally stops. It is not poisonous when taken into the stomach.

Post-mortem Appearances.—The body of persons killed by carbon dioxide usually presents a livid, or very pale, external appearance. The face has sometimes been found swollen and distorted, but usually it is placid and there is no evidence of a struggle. The body is found in an easy, natural position, as though in a sleep at the time of death. The superficial veins are usually prominent, and are filled with dark liquid blood. There is nearly always congestion of the brain and its membranes, with engorgement of the sinuses, as well as of the lungs. The blood is usually liquid and dark-colored. When the source of the poisonous gas is from burning coals, the carbon dioxide is mixed with carbon monoxide, and the blood in this case is bright red instead of dark, and coagulates with difficulty. Putrefaction of the body after carbon-dioxide poisoning takes place slowly, and bodily heat and rigidity are retained an unusually long time. All the internal viscera are usually found congested. Thus far we have discussed the action of carbon dioxide upon the economy when present in the air in sufficient quantity to cause death. When the air is not so largely charged with this gas, the symptoms and effects are less marked, but may still be sufficient to occasion some distress. When the air of a given room or locality contains more than 6 or 7 parts per 10,000, it is to be considered contaminated or impure. An adult man exhales about 0.7 cubic foot (19 litres) of carbon dioxide each hour. This quantity will raise the contents of 3,500 cubic feet of air from 0.4 to 0.6 part per 1,000 each hour. It is evident, therefore, that this amount of air must be supplied to each adult man each hour, in order to keep the air he breathes from having more than 0.6 part per 1,000, or so as not to add more than 0.2 part per 1,000. It has also been found that the air of a room cannot be changed more than three or four times per hour, without causing draughts. Hence ($3,500 \div 4 = 875$) an adult man should have about nine hundred cubic feet of space, for comfort, when proper care is had to ventilation. When air moves more than nineteen inches per second a draft is perceived. If there were no ventilation through walls, which is rarely the case, an open window, having an opening of 6 square feet, would allow 3,420 cubic feet of air to pass, when the draught is barely perceptible; or, enough for a healthy adult man. Parkes, in his "Hygiene," p. 161 (Wood's Library), gives the following figures as representing the average amounts of CO_2 given off per hour by persons of different ages when in a state of repose: For adult males (say 160 pounds), 0.7 cubic foot; for adult females (say 120 pounds), 0.6 cubic foot; for children (say 80 pounds), 0.4 cubic foot; for a mixed community, 0.6 cubic foot. Under these conditions the amount of fresh air to be supplied in health during repose ought to be: For adult males, 3,500 cubic feet; for adult females, 3,000 cubic feet; for children, 2,000; for a mixed community, 3,000 cubic feet, per head, per hour. As more CO_2 is evolved from the body on exertion, these figures are too low for workshops, factories, mines, etc. In mines it has been found that 6,000 cubic feet of air per hour is necessary to keep up the greatest energies of the men. With light work a man weighing 160 pounds throws off 0.95 cubic foot of CO_2 in one hour, while in heavy work the same man would throw off 1.96 cubic foot per hour. This would require for light work the delivery of 4,750 cubic feet of fresh air per hour, and for heavy work, 9,800 cubic feet. The amount of air necessary for cattle, horses, and other large animals, is estimated by Marcker ("Proceedings of Civil Engineers," vol. xii., pp. 298 and 308) as 1 to 1.5 cubic foot per hour for every pound of weight, or 1,000 to 1,500 cubic feet for every 1,000 pounds of weight. For small animals (sheep, dogs, cats, etc.), 150 to 180 cubic feet of air per hour should be supplied for each 100 pounds weight. Birds require even more. The following table, from Parke's "Hygiene," p. 159, shows the amount of contamination produced by one man in different-sized spaces for one hour and each succeeding hour:

Table to show the Degree of Contamination of the Air by Respiration (in Terms of CO_2), and Amount of Air necessary to Dilute to a given Standard of 0.2 *per* 1,000 *Volumes, exclusive of the Amount originally present in the Air.*

Amount of cubic space (= breathing space) for one man in cubic feet.	Ratio per 1,000 of CO_2 from respiration at the end of one hour, if there has been no change of air.	Amount of air necessary to dilute to standard of 0.2 during the first hour.	Amount necessary to dilute to the given standard every hour after the first.
100	6.00	2,900	3,000
200	3.00	2,800	3,000
300	2.00	2,700	3,000
400	1.50	2,600	3,000
500	1.20	2,500	3,000
600	1.00	2,400	3,000
700	0.86	2,300	3,000
800	0.75	2,200	3,000
900	0.67	2,100	3,000
1,000	0.60	2,000	3,000

In hospital wards, where sick persons are confined, ventilation should supply more air than is required by the healthy. This is not due alone to the CO_2 which they give off, but to organic emanations which permeate the air and give it an unpleasant odor and closeness. In hospital wards, Parkes lays down the rule that the quantity of air supplied should be from 4,000 to 4,500 cubic feet per person each hour. The following table from Witthaus' "Chemistry" gives the amount of air which ought to be supplied to each person under the conditions annexed:

Situation.	Cubic metres.	Cubic feet.
Barracks (daytime)	35	1,236
Barracks (night-time)	70	2,472
Workshops (mechanical)	70	2,472
School-rooms	35	1,236
Hospital wards	85	3,004
Hospital wards (surgical)	170	6,004
Contagious and lying-in wards	170	6,004
Mines	150	5,297
Mines (coal)	170	6,004

This table assumes that no artificial light is used; but even in this case, the quantities given are smaller than most physicians would prefer to supply. No hospital ward occupied by a number of persons should supply less than 4,500 or 5,000 cubic feet of air, per person, every hour, and in the case of most septic diseases, out-door air is to be preferred.

Carbon Dioxide from Gas-lights.—A burner which burns 3 feet of gas per hour (ordinary size) produces about 2 cubic feet of CO_2 per hour, and removes a corresponding amount of oxygen from the air. It has been calculated that each burner of the usual form (not Argand) should be supplied with from 4,500 to 5,500 cubic feet of air per hour to prevent contamination with CO_2. Owing, however, to the evolution of heat and watery vapor, and the removal of oxygen, a larger quantity than this should be supplied to keep the air comfortable. A cubic foot of coal-gas produces about from 0.5 to 0.8 cubic foot of CO_2, being rather higher for "water-gas" than for "coal

gas." A burner consuming 3 feet of gas per hour would produce from 1.5 to 2.5 cubic feet of CO_2, a little more than three adult men, or four average persons, would produce. Pettenkofer has determined that a burner consuming 5 feet of gas per hour, giving 12-candle power, gives off as much heat as 8 men, more CO_2 than 3 men, and as much watery vapor as 5 men. Adopting this as a basis of calculation, a 3-feet burner should be supplied with as much air as 3 persons, or about 9,000 feet per hour, to keep the air in a comfortable condition. In reality, this amount of ventilation is seldom obtained in a room of ordinary size. The basis of calculation that has usually been adopted is to furnish 1,800 cubic feet of air for each foot of gas burned. For the same illuminating power, oil does not give a greater degree of contamination than gas. An ordinary lamp gives about the same contamination to the air of a room as one adult man.

Tests for Carbon Dioxide.—The physician may be called upon to test the air of rooms, or inclosed spaces, for CO_2, either for diagnostic or medico-legal purposes. The following simple tests may be employed: A moistened, blue litmus-paper suspended in the air of the room is at first reddened and then bleached by carbon dioxide. If the amount of CO_2 exceed ten or twelve per cent., and has been added to the air, a candle will usually be extinguished. If the CO_2 has been produced by combustion or respiration, the candle will be extinguished by five per cent. An atmosphere in which a candle will burn may be fatal to animals or man. Lime-water or barium hydrate (baryta water) is rapidly rendered turbid on pouring it from one vessel into another in an atmosphere rich in CO_2. A piece of filter-paper dipped in lime-water colored red with phenophtalein is bleached white by CO_2, the rapidity of the bleaching depending upon the amount contained in the air. Or the same colored solution may be poured into a bottle filled with the air of the space as follows: Fill the bottle with water, and pour it out slowly in the room whose air is to be tested, or better, siphon it out, using a piece of rubber tubing as a siphon. One cubic centimetre of thoroughly saturated lime-water should be decolorized by 1.6 litre (1.5 quart) of out-door air, or one litre (roughly) of ordinary in-door air. The air of a room should not decolorize more than 1 cubic centimetre for each litre. The 1 cubic centimetre (15 minims) of colored lime-water may be diluted to 15 cubic centimetres (℥ ss.) with distilled water and poured into a quart-bottle of the air, and shaken up. If the color be discharged, add another cubic centimetre, and so on until a permanent color remains after ten minutes' shaking. Where proper appliances are at hand, it will be much more accurate to use standard solutions of barium hydrate and oxalic acid, using phenophtalein as an indicator.

E. H. Bartley.

CARBONIC ACID WATER, "Soda-water." Carbonic acid water is the product of the solution of carbon dioxide (carbonic acid gas) in water. In such solution there is a chemical union between the gas and the water, molecule for molecule, producing the body *carbonic acid* proper (H_2CO_3), which is known only in solution. At the ordinary pressure of the atmosphere water dissolves about one volume of carbon dioxide, but will take up increased quantities under artificial increase of pressure in direct proportion to the pressure. The carbonic acid water of commerce contains from five to ten volumes of gas forced to dissolve by pressures varying from five to ten atmospheres. Such supercharged solutions appear as colorless aqueous fluids, effervescing briskly on release from confinement, from spontaneous evolution of the excess of carbon dioxide. The reaction is acid and the taste pleasantly acidulous and pungent. Commercial carbonic acid water must, for obvious reasons, be kept strongly confined in well-stoppered vessels, and special care is necessary that there be no exposed surface of lead or copper in the storing vessel, else contamination of the water with those metals will result. A carbonic acid water charged with five volumes of gas was formerly officinal in the U. S. Pharmacopœia, but was dismissed in the revision of 1880.

Carbonic acid water is medicinally valuable as a drink, and as a vehicle for medicines. As a drink its virtues are that, like all acids, it tends to excite the secretion of saliva and buccal mucus, and so relieves thirst more permanently than plain water, and that it is peculiarly grateful to the stomach, tending to expel flatus and allay nausea. As a vehicle for medicines, carbonic acid water is especially adapted for the solution of mawkish salts, such as the purgative salts and alkaline carbonates, bromides and iodides. Not only is disagreeable taste thus disguised, but the salt, whatever it be, is much less liable to disorder the stomach.

It is almost needless to say that all effervescing drinks —mineral waters and sparkling wines or malt liquors— owe their effervescence to carbonic acid formed by the solution in the liquid of carbon dioxide under pressure.

Edward Curtis.

CARBONIC DISULPHIDE, CS_2. This body, commonly called by the older chemical title *bisulphide of carbon*, is now officinal in the U. S. Pharmacopœia as *Carbonei Bisulphidum*, Bisulphide of Carbon. It is thus described: "A clear, colorless, highly refractive liquid, very diffusive, having a strong, characteristic odor, a sharp, aromatic taste, and a neutral reaction. It is insoluble in water; soluble in alcohol, ether, chloroform, and fixed or volatile oils. Sp. gr., 1,272. It vaporizes abundantly at ordinary temperatures, is highly inflammable, boils at 46° C. (114.8° F.), and, when ignited, burns with a blue flame, producing carbonic and sulphurous acids" (U. S. Ph.). The "strong characteristic odor" of the above description, though said not to be offensive in a perfectly pure sample, is, in the article as commonly met with in the shops, of a rotten-egg quality, so disagreeable and so strong as to constitute a practical bar to a common medicinal use of the compound. The high volatility and extreme inflammability are also points of inconvenience, and the latter quality one of danger also.

Carbon disulphide is a powerful agent, of the general type of the volatile alcohols and ethers. It is locally irritant while yet specifically anæsthetic, and, absorbed into the blood, profoundly deranges the nervous functions in the same general manner as chloroform. Habitually absorbed, as may occur by breathing the fumes in india-rubber factories, where the agent is largely used, carbon disulphide produces a peculiar form of chronic poisoning, elaborately described by Delpech as observed in Paris workshops. The poisoning commonly begins by severe headache, sometimes accompanied by an exhilarant intoxication. Later follow depression, mental apathy and dulness, loss of memory, impairment of sight, hearing, and sexual desire, and a very pronounced loss of muscular power. Cramps and various dysæsthesiæ are also common. The poisoning is seldom fatal, but, on the other hand, after full development, entire recovery of health and strength is unusual. Treatment is upon general principles, the only special agent recommended being phosphorus, by the use of which in small doses Delpech thinks he has abated the failure of muscular and virile power.

Medicinally the only properly allowable use of carbon disulphide is as a local application for the relief of surface pains. In this employment the action is like that of chloroform—conjointly anæsthetic and sharply irritant. An application of carbon disulphide causes for a few minutes severe pain, and may or may not be followed by subsidence of a neuralgia. The remedy may be used in vapor by saturating with carbon disulphide a sponge at the bottom of a wide-mouthed flask, and then pressing the mouth of the flask to the skin. Carbon disulphide has been given internally in doses of a few drops, but in the absence of any unique therapeutic powers such administration is certainly not to be recommended.

Edward Curtis.

CARBONIC TETRACHLORIDE, *Tetra-chloromethane, Chloro-carbon:* CCl_4. This body is a colorless, thin, ethereal fluid, of a pleasant aromatic smell, insoluble in water but miscible freely with alcohol and ether. It has been tried as an anæsthetic and has been found to operate

after the general manner of chloroform, but with such a depressing effect upon heart-action that it is little likely ever to come into practical use. *Edward Curtis.*

CARBUNCLE, *Carbunculus simplex seu benignus* (see, also, "Anthrax" and "Boils").

[Some eminent authorities consider simple carbuncle to be a form of anthrax (Anthrax furonculeux), and apply this designation to the local lesion. This seems calculated to create confusion, as the nature and course of the two diseases are widely different; and the essential element of malignant pustule—the bacillus anthracis—is not found in the fluids or tissues in cases of simple non-malignant carbuncle.]

Carbuncle is an inflammation of the connective (cellular) tissue of a greater or less degree of severity, accompanied by the loss of a certain amount of tissue, and exhibiting a tendency to mortification of the skin.

The symptoms belonging to carbuncle are of a much graver character than those attending furuncle (see under heading "Boils"), and are accompanied by more or less significant signs of constitutional disease, such as fever, headache, anorexia, etc. It is always preceded by more or less serious impairment of the general health, by a feeling of malaise, and sometimes by successive chills. These symptoms become intensified until the local disease is manifested by elevation of temperature, redness and swelling of the part, accompanied by a feeling of deep, and at times ill-defined, induration.

When the inflammation has involved an area of a certain diameter, its periphery becomes fixed, and it rarely afterward progresses beyond this boundary. Soon a slight elevation of the epidermis is noticeable, which speedily ruptures and gives exit to a clear gelatinous liquid, which quickly dries and forms crusts about the orifice of exit. This is not accompanied by amelioration of the pain, redness, heat, or swelling, nor does it in the least check the progress of the disease.

As the carbuncle increases in size, the distress, which at first is usually not excessive, becomes gradually more intense, until it reaches a stage when it can be compared to nothing but a violent burning pain located deep in the tissues and accompanied by throbbing and often by agonizing exacerbations. The carbuncle becomes the seat of numerous small openings scattered irregularly over its surface, which lead down to the seat of the disease in the deep tissues of the part. After a time the centre of the carbuncle usually becomes gangrenous. This may be confined to a small portion of tissue, and does not always lead to any considerable destruction in the part; but it usually occasions a loss of substance to a greater or less amount, sometimes reaching an area of twenty-five to thirty centimetres in diameter. This is often accompanied by a notable relief from the pain.

Irregular fragments of necrosed connective-tissue or aponeurosis are often separated during the process of healing, and appear at the orifices upon the summit of the carbuncle, where they are discharged spontaneously, or may be extracted by operative measures. When the necrosed tissues are retained beneath the skin, they frequently give rise to abscesses in the periphery of the original seat of disease, and thus increase the severity of the local lesion and augment the danger to the patient, as well as enlarge the surface to be subsequently healed. The change of the livid color at the border of the induration to a yellow hue is an indication that the disease has reached its limit.

When the gangrenous tissue which forms the centre of the carbuncle has been entirely eliminated, the process of repair commences, by the gradual formation of a cicatrix over the seat of the disease. This is generally a slow process, and in some cases is not completed, on account of exhaustion of the healing power of the system.

The duration of the disease varies according to the age and condition of the patient, and the means employed in its treatment. If the carbuncle is early and thoroughly incised, a complete cure may sometimes be attained in from one to three weeks, although cases often require six months for healing. The average duration of the disease is considered by competent authorities to be from one to two months.

Diagnosis.—In its early stages it may be impossible to differentiate carbuncle from the ordinary furuncle; but the diagnosis would soon be rendered positive by the course of the disease. The furuncle is quite superficial, affects only a limited amount of tissue, may be located upon any part of the body, is not accompanied by grave constitutional symptoms, is developed quickly, is not limited to any particular period of life, and is relieved by spontaneous opening or by surgical incision. The carbuncle, on the contrary, is situated in the deeper tissues, especially in parts like the neck, back, scalp, etc., in which are broad aponeurotic expansions. It usually occurs in patients already the subjects of diminished vitality from other causes, is accompanied by grave and often alarming constitutional symptoms, by high fever and extreme restlessness; it is the seat of great and continuous pain, which is not relieved by the formation of an opening. The inflammation extends a considerable distance beneath the surrounding tissues, and is sometimes followed by extensive gangrene of the superficial structures or by phlegmonous inflammation of the surrounding parts, and is, *par excellence*, a disease of advanced life.

The simple non-specific carbuncle may properly be considered as a group of deep-seated furuncles, which are situated beneath a layer of fascia, and which undermine and cause necrosis of a relatively large amount of tissue, with subsequent gangrene of the overlying skin, sometimes to a very alarming extent. The furuncle has a tendency to heal as soon as an opening occurs; the carbuncle shows no such tendency.

Carbuncle may be confounded with commencing erysipelas, and with a simple phlegmon of the subcutaneous connective-tissue; but these diseases lack the localized character, the surrounding induration, the punctated surface, and the extensive sloughing of a circumscribed portion of connective-tissue. Phlegmon is more boggy and diffused than is commencing carbuncle, the pain and fever are not so marked or constant, and the course of the symptoms is more rapid. Erysipelas is accompanied by a more diffused swelling of the skin, intense redness, and a clearly marked boundary of the disease, with lines of inflammation over the lymphatic channels and infiltration of the lymphatic glands. There is usually no tendency on the part of a carbuncle to extend beyond its original limit.

Carbuncle often presents a striking similarity to anthrax (malignant pustule), and might sometimes be mistaken for this malady, during its early stages, at the time in which a small phlyctenular elevation of the epidermis upon an indurated and swollen base is the only visible variation from the normal condition. But carbuncle is rarely accompanied by the glandular enlargement, by the peripheral or extended œdema, or by so profound signs of constitutional disturbance as is the more grave disease. Aside from these points in diagnosis is the important fact that malignant pustule is observed chiefly, if not exclusively, among those who have been in some way brought in contact with some substance containing the infection, and therefore is more especially confined to those persons who are obliged to handle the flesh, hair, wool, skins, etc., of animals, or to those who are engaged in the care of animals already diseased, as grooms and shepherds (in the grazing regions of North America the disease might be expected among cow-boys). Finally, the dried hides of animals, particularly those received from South America, frequently contain the virus of malignant pustule, and constitute a source of infection to curriers, tanners, and others employed in their manufacture.

The more frequent seat of carbuncle is the neck and back; then the scalp, thorax, face, and limbs. Cases have been reported in which the eyelid was the seat of carbuncle, but these must be exceedingly rare.

Pathology.—Carbuncle may be regarded as the local manifestation of a diseased condition of the general system, being always preceded by a prodromal stage similar in many ways to that of typhoid fever. It has been noticed that other signs of a constitutional affection are often present in carbuncle. Thus Prout observed, in

1840, that the outbreak of the local disease was frequently accompanied by the urinary symptoms of diabetes; though it is quite possible that the diabetic phenomena and the carbuncle may each belong to the outward manifestations of some grave constitutional affection, possibly of some department of the nervous system. The local features of carbuncle are essentially those of a septicæmia, and are to be considered as such as far as prognosis and treatment are concerned.

Prognosis.—In speaking of the lesion of carbuncle allusion was made to the ordinary furuncle as the mildest form of this affection. In prognosis the same relation holds true. The furuncle is superficial in location, runs its course without fever, and is uniformly followed by rapid recovery, leaving a small cicatrix, which is usually but slightly depressed below the level of the surrounding skin. The prognosis of carbuncle, however, depends upon three factors, viz.: the age and vigor of the patient; the gravity of the constitutional symptoms, pain, etc., and the degree of interference with the process of alimentation; and the situation and extent of the local disease and the degree to which gangrene of the skin or sloughing of the deeper tissues occurs.

When the carbuncle is situated upon the neck it may produce dyspnœa by pressure upon the air-passages; when it is located upon the chest or abdomen the pleura or peritoneum may become inflamed; and when upon the face, distortion of the features may ensue; when situated upon the scalp it may be followed by meningitis.

Treatment.—Carbuncle is believed to arise from, or to be accompanied by, a depraved condition of the general health, and therefore the first indication would be to restore as far as possible the normal vigor of the system and to bring about a better nutrition of the body. Some of the most celebrated authorities recommend the employment of active emetics, followed by cathartics, for the purpose of increasing the eliminative function of the digestive canal, and possibly, also, as a means of derivative action upon the seat of the disease. When we consider, however, that the patient with carbuncle is generally already in a state of impaired vigor, any active depletory measures should be either entirely abstained from or carefully watched, lest they induce a dangerous degree of exhaustion or are followed by sudden collapse.

A careful regulation of food, both in regard to quality and quantity, is generally necessary, together with the administration of active tonics and stimulants. The distress is frequently so great as to require the use of anodynes, and frequently the degree of fever is an indication for the employment of large doses of quinine. Cod-liver oil has also been found useful. If rapid exhaustion supervenes, the administration of champagne has sometimes been followed by great benefit. When convalescence is established, iron should be given, a generous and strengthening diet should be ordered, and, if possible, sea-bathing advised.

Locally, the treatment must depend much upon the symptoms belonging to each particular case. At times the application of cold is of great service in relieving the pain and modifying the severity of the inflammation, but generally hot and moist applications are most comfortable to the patient. These may consist of simple hot compresses, but the best mode of treatment is by means of large poultices, which should be frequently changed. At times the local abstraction of blood by means of leeches affords temporary relief, but the bleeding is liable to be excessive in amount, and may induce a condition of collapse.

The surgical treatment of carbuncle should have for its object the liberation of the sloughing tissue in the centre of the carbuncle, and the free opening of all suppurating parts, to allow the easy evacuation of pus. For this purpose many methods of procedure have been advised, such as the circular incision around the base of the carbuncle, the cauterization of the summit of the swelling by means of potash or ferrum candens; the crucial incision of the entire carbuncle, the subcutaneous stellar incision through its substance; and the treatment by compression of the entire carbuncle, or of its peripheral portions, by means of firm or elastic bandages.

The treatment by circular incision consists in cutting a channel quite around the base of the carbuncle, so as to divide the skin and the superficial blood-vessels, and has for its object the diminution of the vascular supply, with the result of relieving the tension and reducing the febrile action in the part, and thus modifying the severity of the process and hastening the recovery. It is more especially to be employed in the early stages of the disease before gangrene has occurred, and while the central slough may yet be quite small.

The application of caustic potash or the hot iron to the summit of the carbuncle has the aim to provide a path for the release of the sloughing centre of the diseased part, and at the same time to avoid the unnecessary loss of blood from hæmorrhage. The tissue to which the cautery is applied is destroyed without bleeding, and the interior of the carbuncle is rendered accessible to direct treatment. This mode of treatment is not often employed, as it is painful in its action and the resulting benefit is comparatively slight.

The crucial incision of the entire carbuncle from base to summit is doubtless a very useful and effectual manner of exposing the interior of the swelling to view, and of liberating the sloughing centre in the most rapid manner. When the operation is completed the carbuncle presents four deep incisions radiating from the centre to the periphery. By this means the whole interior of the diseased part is made accessible to direct treatment, and the most favorable conditions for rapid and complete recovery are at once established. The incision of the skin over the inflamed part, however, is attended with a considerable loss of blood, which in the debilitated condition of many of the subjects of this disease is of no small importance. To obviate this, and thus to save the strength of the patient, the method of subcutaneous stellar incision has been adopted in most cases of extensive carbuncle.

This mode of treatment consists in the internal division of the seat of disease into many small sections, and has for its object the rapid and easy evacuation of the sloughing tissues of the centre of the carbuncle and the liberation of purulent matter, with the avoidance of excessive hæmorrhage.

In performing this operation the surgeon makes use of a long and narrow knife, which is inserted into the perforated centre of the carbuncle and carried directly to the bottom of the disease. Its point is then directed outward toward the periphery of the carbuncle, and when the external boundary has been reached the edge of the knife is turned toward the skin, and the tissue is carefully cut from below toward the surface. The incision should not be allowed to reach the skin, on account of the bleeding which would ensue, but should comprise all the diseased tissues below the skin. This process should be repeated in all directions until the carbuncle consists of only a superficial covering of sound skin overlying the thoroughly divided and broken-up mass of the carbuncle. The amount of hæmorrhage is very slight. The free division of the diseased tissues is followed by the rapid separation of the gangrenous portions, and if the strength of the patient is not too much reduced, recovery is usually rapid and complete.

The application of moist heat, preferably in the form of poultices, should follow any operative measures, as the separation of the sloughing portions is accelerated by warmth and moisture, and the process of repair is hastened. Should the necessity for disinfection arise, this may be accomplished by the use of chlorinated soda, which is preferable to carbolic acid, on account of the somewhat greater danger of poisoning by this agent in carbuncle than in ordinary surgery, owing to the more extensive surface for absorption and the age and weakened condition of the patient. If it should become desirable to employ an antiseptic, a solution of mercuric bichloride may be used in the wound, in the strength of one part to two thousand or four thousand parts of water, without danger of grave intoxication.

The cicatrix following carbuncle is generally more or less depressed, and may at times become so retracted as

to produce deformity, and occasionally to interfere with the functional activity of parts or organs (neck, jaw, eyelid, etc.). *Albert N. Blodgett.*

CARCINOMA (PATHOLOGICAL ANATOMY). The carcinoma may be defined as a tumor which is chiefly composed of true epithelial cells; but which cells, instead of growing in a manner conforming to the normal epithelial structures, grow in an irregular atypical manner. The structure of a carcinoma can never imitate exactly any typical epithelial structure, as for example, a gland. Remak first showed that at a very early period in the life of the embryo, the blastoderm was divided into three layers, and from these three layers all the tissues of the body were formed. He held that this law applied not only for all physiological growth, but also for the pathological formations. Thiersch founded his theory of the development of the epithelial carcinoma on this law of Remak's, regarding it as a true epithelial growth proceeding from the epidermis. He regarded the law of Remak as a true histogenetic law which must hold good for all life; a tumor, for instance, whose chief constituents were epithelial cells, could only arise from an epithelial structure. What Thiersch did for the epithelial carcinoma Waldeyer did for the glandular carcinoma. He studied particularly the carcinoma of the mammary gland, and showed that it was a true epithelial tumor, and originated in the glandular epithelium. Formerly the whole question was very much confused by the uncertainty of the definition given. The name cancer and carcinoma were used synonymously, and were applied to all malignant growths. Since the anatomical study of the new-formations, and especially their histogenesis, was taken up and so highly developed by Virchow, we know that only the anatomical structure of a tumor can tell us anything as to its nature. Most modern pathologists are agreed that only such tumors can be called carcinomas whose chief constituents are epithelial cells arranged in a peculiar manner, and to this most authorities have added that they must be derived from true epithelium. Remak's theory of development has of late undergone various modifications, but these have only served in many instances to make more clear the epithelial origin of the carcinoma. Many structures which were formerly believed to originate in one layer of the blastoderm are now known to proceed from another. It was well known that there could be a true carcinoma on surfaces covered by endothelium, as on the pleura, peritoneum, etc., and these structures were not covered by epithelium but by endothelium, which was formed from the mesoblast. Now, it is known that there is no real distinction between epi- and endo-thelium, and both are formed from the same embryonic tissue. Thiersch and Waldeyer have been the chief exponents for the theory of the epithelial origin of carcinoma, and their views have been adopted by a number of other German pathologists, as, for example, Ziegler, Birch-Hirschfeld, Billroth, Klebs, and others.

On the other hand, there are a large number who believe it can originate from any tissue at will, and, indeed, that normal epithelial structures can originate in connective-tissue, or in the muscle elements of the vascular walls, etc. Among these authors may be mentioned Rindfleisch, Volkman, Lücke, Eberth, Gussenbauer, and Weil. Virchow held that the carcinoma, like all other tumors, was formed from the connective-tissue. In France, Cornil and Ranvier separate sharply the glandular carcinoma from those seated on the surface, and regard the glandular growths (which they designate as carcinoma in contradistinction to epithelioma, the surface growth) as true connective-tissue tumors. As a strong point in favor of the theory which finds in connective-tissue the mother-tissue of the carcinoma, we have the fact of this tumor being found primarily in bone, muscle, etc. There are a great number of such cases reported. There is no doubt but that in a number of these cases the primary tumor may have been so small as to be overlooked at the autopsy, and what really was a secondary growth may have been mistaken for the primary. Again, the tissue of some of the sarcomas approaches so nearly to that of the carcinoma that a mistake in diagnosis may have arisen in this way. Still there are other cases which cannot be so explained. The writer once saw a case in which a nodule the size of a walnut, and of a soft medullary consistency, was found enclosed in the sternum. The most careful search failed to find elsewhere in the body a tumor of any sort, and on microscopic examination the sternum tumor showed the most typical carcinomatous structure. Such cases can, however, be explained in accord with the theory of Cohnheim, that here some epithelial elements had been deposited in an early period of embryonic life, and they had afterward developed into a carcinoma. (See article on Tumors.)

Much of the uncertainty which prevails in reference to the histogenesis of the carcinoma is due to the complex character of its anatomical structure. In most of the other tumors we have but a single tissue to study, here we have two. As we have said, its principal constituents are epithelial cells, or cells similar in appearance to these. These cells are arranged in alveoli, which may be round, more or less elongated, club-shaped, etc., and these masses of epithelial cells grow into the surrounding tissues in the same way as is the case in the fœtus. The single cells, of which the alveoli are composed, are in close contact with each other, and no other tissue enters into the alveoli. This must be regarded as the chief distinguishing mark between the alveolar sarcoma

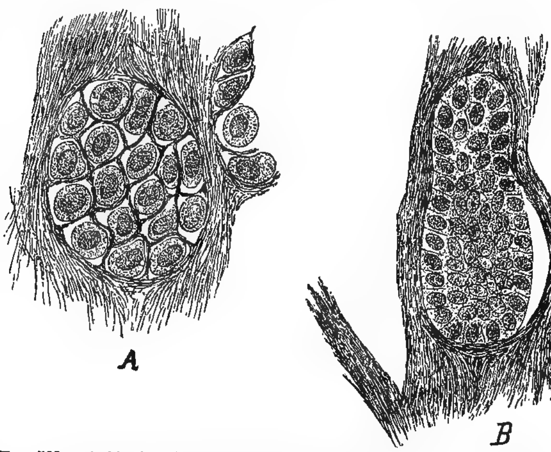


FIG. 560.—*A*, Single Alveolus from an Alveolar Sarcoma of the Upper Jaw. A distinct reticulum of connective-tissue is seen between the cells. *B*, Single Alveolus from a Carcinoma of the Mamma. The cells are in close contact with each other, and, in one place, have shrunken from the alveolar wall. (× 300.)

and the carcinoma. The cells of the alveolar sarcoma may be exactly similar to epithelial cells, and the alveoli, as seen under a low power, may be as sharp and distinct as in the carcinoma; but with higher powers we see that the cells in the alveoli are more or less separated from each other by threads of connective-tissue, and in some cases capillaries can be traced into them.

We must consider another tissue which plays an important part in the carcinoma, and that is the tissue which lies between and separates the alveoli. In some cases this is well-formed connective-tissue, but in others it consists of a tissue very vascular and rich in cells, similar to the undifferentiated tissue of the embryo. It is a well-known fact that connective-tissue cells under the influence of chronic inflammation, may take on forms which greatly resemble epithelial cells; one has only to look at the so-called epithelioid cells of the tubercle, or the cells in the submucous coat of the intestine, in cases of dysentery, to be convinced of this fact. Similar conditions are also sometimes seen in the interalveolar tissue of the carcinoma, and have been interpreted by many as showing the change of connective-tissue into true epithelium. We find everywhere under the influence of chronic inflammation and irritation, a connective-tissue in all respects anal-

ogous to this interalveolar tissue; in some cases hard and indurated as the tendon, in others taking the type of embryonic connective-tissue, and in others filled with epithelioid cells. It is composed of the old connective-tissue of the part in which the carcinoma has originated. Of course, under the influence of the chronic inflammation caused by the growth, it proliferates just as any other tissue, and we always have this new formation of connective-tissue accompanying the epithelial growth. In the narrow sense we might say that it formed no integral part of the tumor; that the tumor was the epithelial growth, and the other was incidental to this. The cells of which the alveoli are composed are, as we have said, epithelial in character, but they have no definite typical size or shape. This depends for the most part on the character of the epithelium from which they took their origin, but is influenced by other things. When a portion of a rapidly growing carcinoma of the mamma is examined under a high power we find cells like those represented in Fig. 561—large, palely granular cells, which may be round, caudate, or even approaching a spindle in form. Usually there is only one nucleus present, and this is sharply separated from the protoplasm of the cell and provided with one or more strongly refracting nucleoli. In most cells a number of fat drops will be found. The shape of the cells is obviously influenced by the mutual pressure to which they are subjected in the alveoli. This, then, is the characteristic of the carcinoma: groups of epithelial cells of various sizes and shapes lying in a stroma formed of connective-tissue more or less altered. This alone will enable us to diagnose a tumor as a carcinoma. From an examination of the cells alone we can tell nothing. No connective-tissue and no blood-vessels penetrate the groups of epithelial cells; the single cells are in close contact with each other. All nutrition must come from the abundant vessels in the stroma, and, in consequence of this, the outermost cells of the alveoli are the best nourished, being nearest the blood supply. The larger the alveoli become, the worse is the nutrition of the cells in the middle, and we often have four or five rows of cells, whose nuclei stain brightly, surrounding a fatty caseous mass. All growth takes place in this well-nourished circle, all new cells are formed here, and the cells in the middle are the oldest. It may be regarded as analogous to the rete Malpighii of the skin. In studying nuclear division by the cariokinetic figures, we only find these figures in the outside cells. Where cells are by their nature destined to undergo various metamorphoses, as in carcinomas which have their origin in the epithelium of the skin, we find the cells in the middle of the alveoli flat, and with all the characteristics of the horny layer of the epidermis.

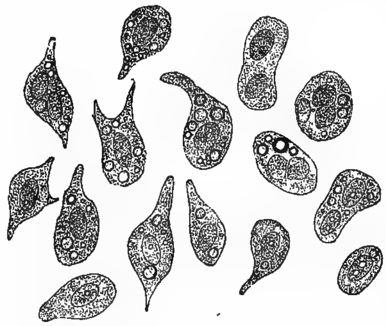


FIG. 561.—Cells from a Rapidly Growing Carcinoma of the Mamma, Examined in Salt Solution. (× 400.)

When we make a section through the middle of a carcinoma and lightly scrape the cut surface with a knife, we obtain a milky-looking fluid, which, on examination, will be found to consist of fat globules and epithelial cells. This is the cancer-juice on which so much stress has been laid as diagnostic of cancer. Using the word cancer in a clinical sense merely, as designating a malignant tumor, the presence of this juice is of much moment, but it is not at all diagnostic of the carcinoma. We can obtain from nearly all of the sarcomas such a juice, and generally in greater amount than in the carcinoma. It depends on the loose connection between the cells and the formed tissue which enables us to separate them. Where that connection is a close one, as in the fibroma and chondroma, it is obviously impossible to obtain such a juice.

We have said that the carcinoma is an atypical epithelial growth, but the reverse of this is not true; all atypical epithelial growths are not carcinomas. We must have something more added to this—we must have the capacity for unlimited growth, for invading and destroying adjacent structures, and for producing in a distant part of the body similar growths—before we can call such a growth a carcinoma. Friedlander has made most careful researches upon this subject; he finds a growth of epithelium extending downward into the tissues in all cases in which the normal condition of the underlying tissues is altered. It would seem that this tendency to unlimited growth is inherent in the epithelium, and is only kept in check by the resistance of the neighboring tissues. Thiersch explained the frequency of epithelial carcinomas in old people by supposing that old age diminished the physiological resistance which connective-tissue offers to the growth of the epithelium. It is probable that the irritative action of the growth of the carcinoma alveoli into the surrounding tissue, as evidenced by the small-cell infiltration, etc., produces changes in it favorable to its further growth. Cohnheim has, indeed, found in this want of physiological resistance of the tissues the chief criterion of the malignant tumor. We may have in the skin covering a lupus or leprosy nodule a proliferation of the epithelium, which will appear, on microscopic examination, exactly similar to carcinoma. But the growth is only a limited one, and ceases so soon as the connective-tissue is restored to its normal condition.

The carcinomas have been given various names to designate the differences which exist mainly in their microscopic appearances. These differences are due to varying relations between the alveoli and the stroma, or to some change which has taken place in the stroma. There are sufficient differences between those carcinomas which originate in the surface epithelium and those of glandular origin to allow us to consider them separately. This distinction is no absolute one; we cannot, for example, separate those originating in the sebaceous glands and the crypts of Lieberkühn from those on the surface.

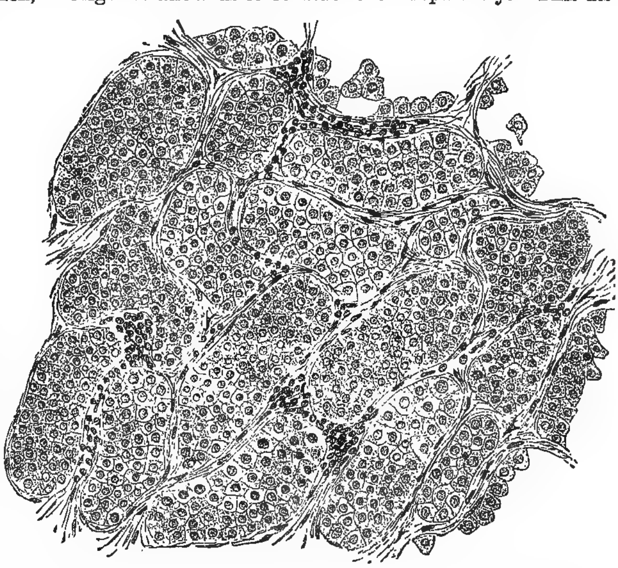


FIG. 562.—Section of a Medullary Carcinoma of the Mamma. (× 175.)

The carcinomas originating in the surface epithelium (epithelioma) can be divided into the pavement-cell and cylindrical-cell varieties. The pavement-cell epithelial carcinomas form warty nodular growths seated on the surface of the skin, or on the mucous membrane of the mouth, œsophagus, lower rectum, etc. On section they

have a white, pearly color, and on scraping them with a knife we obtain small, round, hard bodies, which, on microscopical examination, are found to consist of concentric masses of horny epithelial cells. The mode of origin of the tumor can be studied from sections of small nodules, which also include some of the adjacent skin. The Malpighian layer of the skin sends down long processes into the connective-tissue; these processes branch

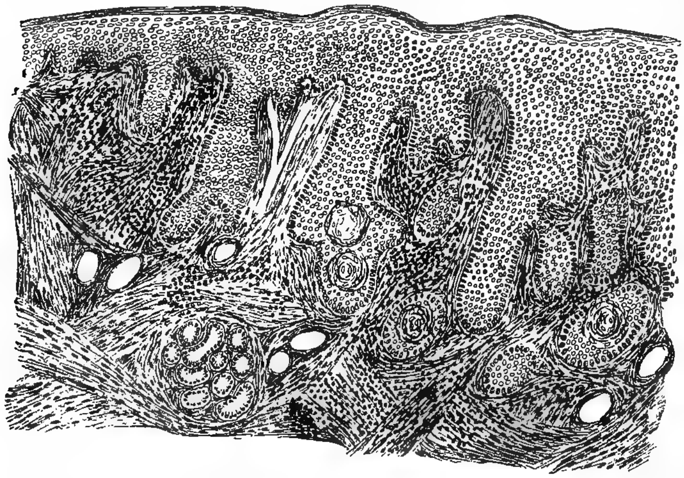


FIG. 563.—Section from the Edge of an Epithelial Carcinoma of the Cheek. At various places a small cell-infiltration of the connective-tissue is seen.

and traverse the skin in every direction. Frequently the epithelial growth forms one connected mass, as may be seen by studying series of sections. Most often, however, small portions become cut off in the course of growth, and these form new centres. Between these groups of epithelial cells we find a connective-tissue, sometimes fully developed and showing no evidence of growth, at other times filled with cells and newly formed blood-vessels. Each of these alveoli of epithelium almost repeats the structure of the skin. On the outside we have rather cylindrical cells with brightly staining nuclei, and within, the cells become flatter as they approach the middle. Their edges are interlaced with each other by slight projections, and in no tissue can these "Stachelzellen" be better studied than in such a carcinoma. The interior often contains the small, round pearls which we have said could be obtained by scraping the surface. These pearls were supposed to be characteristic of the pavement epithelial carcinoma, but we know now that they will always be found in any epithelial growth which takes place under the same conditions. The ramifications of the epithelial growth remind one of the network of lymphatic vessels in the skin, and Köster has supposed that the cells are derived from their endothelium. By means of nitrate-of-silver injections he has shown that these alveoli were often in direct continuity with the lymphatics, and in the cases in which the epithelial growth was apparently a continuation of the Malpighian layer, he supposes that this is a secondary result from the fusion of the tumor with the skin. It is true that this connection with the lymphatics is a very close one, but it by no means follows that the lymphatics play an active part in the growth. The alveoli in their growth are sure to follow in the line of the least resistance, and having early broken through into the lymphatics, grow along and in these. There are various minor differences in the epithelial carcinomas, depending on the part of the body in which they originate.

The cylindrical-cell carcinoma is seated on mucous surfaces, especially on the mucous surface of the intestinal tract and the uterus. They form soft medullary tumors, and generally originate in simple glands lined with cylindrical epithelium. Probably in most cases the tumor starts as an adenoma; the first growth is a typical one, and the structure of the gland is repeated. Later the alveoli become filled with cells, the glandular character is lost, and they grow out into the surrounding tissues. We have a similar history frequently in the pavement-cell carcinomas. These frequently originate in simple papillomas; when from any cause the growth of the epithelium takes place in the opposite direction downward into the cutis, it becomes the atyptical carcinoma. In carcinoma of the bladder this can frequently be seen. We can have at the same place a papilloma and a carcinoma. The name adeno-carcinoma has been given such tumors in the intestinal tract, and the name papillo-carcinoma might with propriety be used to designate an analogous condition in the pavement-cell carcinomas. The alveoli of the cylindrical-cell carcinomas of the uterus are large and round, the cells on the outside retain completely their cylindrical form, and those within are more or less altered from pressure, and, as a rule, are in an advanced state of degeneration. It is needless to remark that in the cylindrical-cell carcinoma we do not have the formation of pearls.

As much as the purely glandular carcinoma, if we take that of the mamma as a type, may differ macroscopically from the surface carcinoma, their modes of origin and microscopic structure are about the same. There is first a growth of the epithelium into the lumen of the gland, and then an epithelial infiltration of the surrounding tissues. The whole process can best be studied on great sections, embracing both the tumor and the adjacent healthy structure, with a low power. We then see in place of the small acini great groups of carcinoma cells of different sizes and shapes embedded in a scanty stroma. From these primary foci the infiltration of the connective-tissue extends beyond the limits of the gland. The spaces in the connective-tissue are widened and pressed apart by the epithelial invasion which partly takes place in the form of round, club-shaped projections, and partly as long, thin processes. This extends along the large gland-ducts and infiltrates the cutis, especially in the region of the nipple. A new formation of connective-tissue accompanies this epithelial growth, and from its subsequent contraction the retraction of the nipple, so important a sign of the mammary carcinoma, results. Only at the edge of the growth, and in general far away from the place it originally occupied, do we find a few unchanged acini. The growth is seldom uniform, generally we find large masses of the carcinomatous tissue

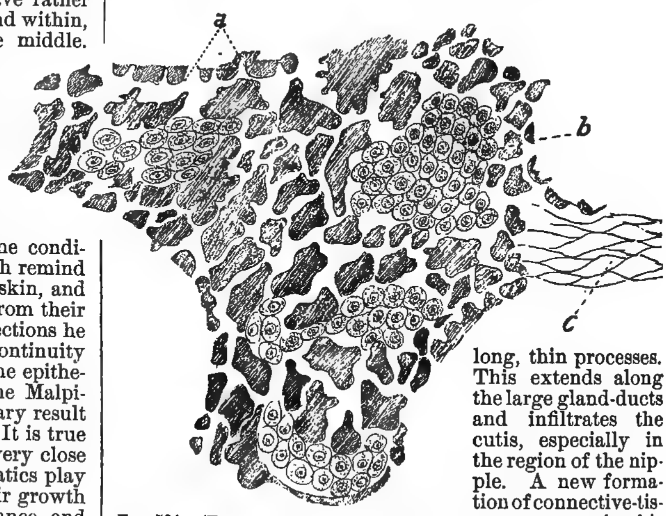


FIG. 564.—(From Cornil and Ranvier.) Section of a Carcinoma of the Mamma Treated with Nitrate of Silver. a, Lymph spaces in the connective-tissue; b, carcinoma cells; c, lymph vessels.

separated by great bands of connective-tissue, processes from which enter between the single nests of cells. These groups seem to correspond to the original lobules of the gland. The connection between the alveoli of the glandular carcinoma and the lymphatics is as close as in the pavement epithelial carcinoma. On sections of the periphery stained with nitrate of silver this connection can clearly be seen (Fig. 564).

There are a number of sub-varieties of the carcinoma which present some differences, depending often on degenerative processes; these we will briefly mention.

By the term carcinoma simplex we understand a variety of glandular carcinoma which forms nodular tumors of a tolerably firm consistency. On being cut they are of a grayish white color. The aveoli are generally large, and, when they have undergone fatty degeneration, can be distinguished by their opaque white color from the tissue of the stroma. An abundant cancer juice can be pressed out of the cut surface. The connective-tissue stroma is well defined. Such tumors make up the majority of the carcinomas of the mamma; they are also frequently met with in the kidneys, pancreas, and other organs. Another form of carcinoma is designated as the medullary, from its resemblance to brain tissue. It is soft and can easily be crushed between the fingers. The juice always shows cells in a high state of fatty degeneration. On section we find large alveoli, filled with cells, more or less fatty-degenerated. These alveoli are separated from one another by a slight amount of connective-tissue. Some of the sarcomas are microscopically very similar to these tumors, and have been very often confounded with them and called medullary cancers, "Markschwamm." Such tumors are most often found in the testicle, and a careful microscopic examination will nearly always show them to be not carcinomas, but alveolar sarcomas. It is the excess of cells over formed tissue and the fatty degeneration of these cells which give them their softness. Just the opposite to this is observed in the scirrhous carcinomas. These form intensely hard nodules of almost cartilaginous consistency. It is almost impossible to obtain any juice by scraping the cut surface. On microscopic examination we find small, narrow groups of epithelial cells embedded in a dense, firm connective-tissue, which sometimes has the appearance and consistency of cicatricial tissue. No sharp distinction can be drawn between the scirrhous carcinoma and the carcinoma simplex. In each, some places may be found which belong to the general histological character of the other. It is most probable that the scirrhous nature of the tumor was not apparent in the beginning, but that it is due to a number of the alveoli undergoing complete fatty degeneration and absorption, in which case their place would be taken by the dense connective-tissue. It often seems in the scirrhous carcinoma that the growth has reached a standstill, and that the shrinking and cicatrization still go on. This condition cannot be considered favorable to the prognosis, for just such tumors are most often followed by the most extensive metastases.

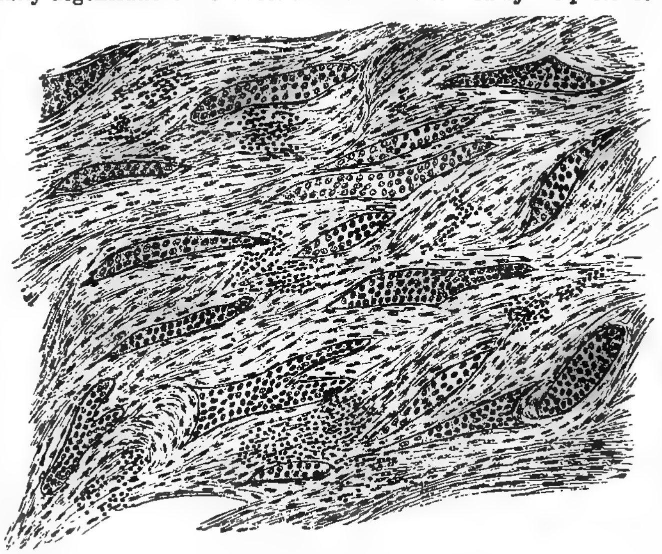


Fig. 565.—Scirrhous Carcinoma of the Mamma.

The cells of a large number of carcinomas undergo a colloid degeneration. They become, in consequence of this, swollen up to an enormous size and transparent. In consequence of the transparency of the cell-groups, the opaque stroma is rendered much more prominent, and hence these tumors are sometimes designated alveolar carcinomas. The colloid matter is deposited in the cells first in the form of small drops, which increase in size until the whole cell is destroyed. The drops then flow together and form large homogeneous masses. When these tumors are seated on mucous surfaces, their nature is sometimes apparent from the surface. The whole tumor beneath the mucous membrane has a semitransparent aspect. In most cases it can only be recognized after section. Generally only a part of the tumor shows this change and is transparent, while the other part has the ordinary grayish-white color. We have at other times an almost similar condition of the stroma, due to myxomatous degeneration. Then the stroma is represented by a hyaline homogeneous structure which encloses stellate cells. A mucous degeneration of the epithelial cells can accompany this. This form of tumor is relatively rare, the writer having seen it but once, and then in a carcinoma from the mamma of a dog. We may have hyaline bodies similar to those found in the cylindroma, in the middle of the nests of epithelium, and this has given rise to the name of cylindroma carcinomatodes. Such tumors usually proceed from glands whose epithelium is wont, under ordinary circumstances, to undergo this hyaline degeneration, as in the thyroid gland. The melanotic carcinoma is characterized by the presence of a peculiar black pigment in the epithelial cells and in the stroma. The tumor is of a grayish-black or black color. These tumors are exceedingly rare; by far the majority of all melanotic tumors belong to the sarcomas.

The carcinoma soon infiltrates and substitutes its tissue for that of the organ in which it has appeared, but its growth is not limited here. The densest capsules, the firmest fascia, offer but slight impediments to its growth. A carcinoma on the skin over the tibia attacks and destroys the bone, and we see the same thing in carcinoma of the mamma where the cartilages and ribs themselves give way before it. Its destructive process is withstood for some time by the arterial walls; we may see the axillary artery running through a mass of carcinomatous glands in the axilla, perfectly intact. The growth enters a tissue along the blood-vessels or lymphatics and destroys it by substitution. The cells of the carcinoma have a superior affinity for the nourishing materials of the blood, and they live at the expense of the tissue invaded. Sooner or later the lymph-glands of the part, as the axillary glands in carcinoma of the mamma, or the gastro-hepatic glands in carcinoma of the stomach, swell up and become indurated, and on section we find a typical carcinomatous structure. This invasion of the glands takes place earlier than is generally supposed, and before any macroscopic signs show themselves. The writer has often examined glands from the axilla, no larger than a pea and perfectly normal in appearance, in which a typical carcinomatous structure was found on microscopic examination. It is not uncommon to find the lymph-glands connected with the primary tumor by a hard, firm cord. This is a lymphatic vessel which has become carcinomatous. Sometimes not a perfectly formed cord is found, but a series of little nodules between the gland and the tumor. That this invasion of the glands is due to materials brought from the tumor to the gland, is shown by the periphery of the gland, the part through which the material would

have first to pass, being first attacked. The single glands become adherent to one another, their normal structure disappears entirely, and there remains nothing but an irregular nodular mass. In the lymph-glands we have an exact repetition of the primary tumor. If there was any peculiarity in the form of the cells in the primary tumor it is repeated in the glands; even peculiar forms of degeneration, such as the colloid metamorphosis, are often repeated. It is most generally believed that the invasion of glands is due to cells or collections of cells being carried into the glands by the lymphatics coming from the tumor. Gussenbauer has studied this process very carefully and comes to a different conclusion. He thinks the infectious power lies not in the cells themselves as such, but in certain small refracting bodies which he always finds in the cells of carcinomas. These small protoplasmic masses come in contact with the cells of the gland and incite these to a carcinomatous growth, acting in this way as some of the bacteria are supposed to act. The infection of the lymph-glands follows the glandular carcinoma much earlier and more certainly than the epithelial carcinoma. In the epithelial carcinoma of the lip it is often wanting.

After the invasion of the lymph-glands, and in some cases without it, there takes place a metastasis in the internal organs. Of these the liver and the lungs are most often affected. When the primary carcinoma is seated in an organ connected with the portal circulation, the liver is almost sure to be infected. The epithelial cells are carried there by the portal vessels, and grow in the liver just as they did in the mother tissue. These metastases always repeat the structure of the primary tumor. In the liver they form white nodules, sharply separated from the liver substance, and may be of any size; some so small as not to be visible without the aid of the microscope, others larger than a fœtal head. The manner of growth can best be studied in those of very small size. The epithelial cells are always contained in the capillaries of the liver; by constant growth of the epithelial masses the capillaries are distended, and the liver cells between them undergo atrophy and disappear. In the larger tumors there is but a very small amount of connective-tissue between the alveoli. The connective-tissue of the liver show signs of activity, but not such as would lead us to suppose that a change into carcinoma cells was taking place, but rather a new formation of the connective-tissue. New blood-vessels have to be formed, for the portal capillaries are taken up by the meshwork of the tumor. These new vessels are mainly derived from the system of the hepatic artery, and we can always obtain a more complete injection of a nodule from this than from the portal vein. All the changes which take place in the liver cells are of a retrogressive character; they usually undergo simple atrophy from pressure. It is possible, and indeed probable, that a metastatic nodule in the liver may act as a primary tumor, and in its turn give rise to metastases, both along the lymphatics of the liver and along the blood-vessels. We often meet with lymphatics in the interlobular spaces filled out with tumor cells, and it is more reasonable to suppose that the cells which they contain are derived from nodules in the liver than from the primary tumor. Cells may also be carried into the right heart by the hepatic veins, and from here into the lungs, where they also produce metastases. When a carcinoma breaks through into a large serous sac, as the peritoneum or pleura, we often have the whole surface covered by innumerable small nodules which do not exceed the size of tubercles and resemble them macroscopically, though on microscopic examination they show a typical carcinomatous structure. Sometimes the metastases may be so great in number, and so small, as to resemble an acute miliary tuberculosis. In such cases no organ is exempt from them—brain, lungs, liver, kidneys, the medulla of the bones, all contain them. Such a condition is called miliary carcinosis, and is brought about by large quantities of the cells getting into the systemic circulation. Very often a nodule with an ulcerated surface will be found on the valves of the left side of the heart, and from this the general infection followed.

Retrogressive changes of all sorts are common in carcinoma. As we have said, the juice obtained by scraping the surface always contains cells in a greater or less degree of fatty degeneration, and some which are entirely broken down. This fatty degeneration is even visible to the naked eye, the places affected by it being distinguished from the rest of the tumor by their whitish, opaque color; these spots are also often so much softened as to form semi-diffluent masses. In other cases a condition very similar to tubercular caseation is met with, and by the absorption of these degenerated portions the formation of cavities, or great shrinkage, may result. In tumors which are seated beneath the skin a central depression is often produced by this process of absorption. A connective-tissue of a dense cicatricial character takes the place of the absorbed portion; as very few alveoli are contained in this, on section it appears like a scirrhus. There is another degenerative process more important than the fatty degeneration, that is, the necrosis of the tissue, and the ulceration caused by this. In rare cases this may be beneficial to the organism, as by means of it whole tumors are sometimes destroyed, but in the majority of cases it is the reverse of beneficial. We sometimes find in the intestinal tract extensive ulcerations at the seat of the tumor, and scarcely any of its tissue remaining. If the ulceration has not been very extensive at the bottom of the ulcer, the tumor may be seen in the shape of nodular projections. If, on the other hand, the ulceration has been very deep and extensive, we can often scarcely decide with the microscope whether we have to do with a simple or a carcinomatous ulcer. Ulceration in tumors seated beneath the skin is seldom so extensive as in the intestinal tract. The necrosis is caused by the circulation of a large area of the tumor being cut off, either by pressure of other growing parts, or by thrombosis of its vessels. Necrotic changes, limited to very small areas, are probably constantly in progress, though in such cases the necrotic portions are absorbed and no ulceration produced.

The blood-vessels of the carcinoma seldom are the typical arteries, capillaries, and veins. The capillaries are very numerous, and are usually wider than in the normal tissues, with frequent ampulla-like dilatations. The various disturbances of the circulation, as inflammation, hæmorrhage, congestion, etc., are common here.

W. T. Councilman.

CARCINOMA (PATHOLOGY, CLINICAL HISTORY, ETC.).—From a purely clinical point of view there is much vagueness about the word "cancer," because it has been frequently held, by English writers more especially (Purcell[1] and others), to include malignant growths of any description. On the other hand, modern pathologists have been equally disposed to narrow its significance and make it the equivalent of *carcinoma*, which represents to them a new formation that is epithelial in its type; while a sarcoma or myxoma, or an enchondroma, etc., as the case may be, from which carcinoma is more particularly to be differentiated, indicates a structure of the connective-substance type or group. Hence a little confusion has crept into medical terminology, occasioning some embarrassment in the study of the disease.

There is, however, a marked tendency among the profession at large toward maintaining the well-drawn distinction between these several growths which the pathologists have established—at least in all cases in which the special histological structure of the specimen has been determined; and there can be no doubt that in the future, whatever classification is adopted, it will be founded upon such characteristics as are revealed by the microscope. In this article the term "cancer," when used, will have no reference to any form of disease other than that of carcinoma in its strictest sense.

Carcinoma embraces four principal divisions or varieties, viz.: epithelioma, scirrhus, medullary or encephaloid, and colloid. In this matter there is a pretty general agreement, but there is not the same amount of unanimity as to the proper position that some of the subordinate forms of the disease should occupy in a scientific category. This

may be said with special reference to rodent ulcer and cauliflower growths,* and yet it will appear that the matter of classification is really of secondary importance, because each form, after all, has to be studied by itself, and in connection with certain clinical phenomena.

1. Under the general heading of epithelioma there are three distinct subdivisions: *A*, rodent ulcer or cancer, also called cancroid and flat epithelioma; *B*, deep or squamous epithelioma, known also as perforating ulcer, lupus non-exedens, etc.; and *C*, cylindrical epithelioma, or cylindrical carcinoma (cauliflower excrescence).

A. Rodent ulcer originates in and affects chiefly the epidermis. Its chosen seat is the face, commonly the eyelid or parts adjacent; less often the temples. There seems to be no good reason why other parts of the skin should not be attacked by rodent ulcer, but it is seldom seen elsewhere than in the places that have been named. The disease is comparatively slow in growth, can be removed by various simple operative procedures, recurs after a considerable interval, if at all, and, even if it does return, may be held in abeyance for many years by suitable therapeutic measures. To some English writers it is known as rodent cancer (Moore[2]), and it is occasionally dubbed by the doubtful name of lupoid ulcer, though it is a matter of satisfaction that this name is now getting to be obsolete. In rodent ulcer (cancer) the epithelial cells of the rete mucosum, or mucous layer of the skin, play an important part in the origin and development of the growth, and there is a tendency to the aggregation of the cuboidal cells in laminated capsules, though they rarely exhibit the peculiarly concentric formations known as "birds' nests," which characterize the typical squamous epithelioma. From their occasional occurrence, however, some observers, such as Mr. Arnott,[3] claim that we have no sufficient warrant for placing rodent ulcer apart from squamous epithelioma. Nevertheless, while the pathological histology of rodent ulcer does not always furnish adequate ground for instituting a sharp distinction between it and the squamous form, the clinical histories of the two involve points of great and noteworthy difference (Warren,[4] Tilbury and Thomas Fox[5]). (See Epithelioma of the Face.)

B. The deep or squamous epithelioma is best exemplified when cancer attacks the lower lip, penis, or vulva. In such cases the interpapillary spaces of the epidermis deepen and appear to penetrate the true skin, while the papillæ proportionately elongate. At the same time all of the epithelial elements of the skin increase by proliferation, and in the prolongations of the rete especially there are developed in the mature tumor "concentric globes" of squamous epithelium, of such dimensions that they can be seen by the naked eye. These "globes," or "birds' nests," are regarded as pathognomonic of squamous epithelioma. The deposit is extensive, as compared with that of rodent ulcer, and the adjacent lymphatic glands are extensively implicated when the disease reaches maturity.

C. Cylindrical epithelioma, or cylindrical carcinoma (cauliflower growths), occurs chiefly in the cervix uteri, bladder, or rectum. Its favorite seat is in the cervix, where it originates as a pedunculated or sessile vascular wart. It grows with great rapidity and soon attains a large volume. Though classed among the epitheliomas, it is rather because it originates from the epidermal layer than because it resembles the two varieties just described, for in cauliflower growths there is no tendency to the formation of "concentric nests." On the other hand, it is sometimes found to be allied to scirrhus, because at the base of the tumor an alveolar arrangement of the epithelium, similar to that in scirrhus, is found, after the disease has progressed to a certain point. It is mainly composed of cylindrical cells in one or more layers, covering slender, branching stalks, that are well supplied with nutrient blood-vessels. Each tumor varies as to the character of its cylindrical cells, the thickness of its stalks, and the amount of its blood supply.

2. The second of the principal divisions of carcinoma is scirrhus. It is the most common of all and has numerous subdivisions, at least according to the writers who have described it, for they speak of nodular, diffuse, and atrophic scirrhus, besides many other forms, though these terms seldom have any value as indicating a special clinical character. It is most common in the female breast. (See Carcinoma of the Breast.) Microscopically it is found to consist of a system of anastomosing channels in the connective-tissue substance, each channel being packed more or less completely with epithelial cells of the glandular type. These spaces are the lymphatic channels or canaliculi, which have been utilized by the epithelial growth in its advance from some pre-existing normal epithelial structure. The epithelial bodies are mostly of large size, and in various degrees of perfection, according to the age of the cell and of the growth, each individual element degenerating more or less after the disease has progressed toward maturity. But the distinctive characters of scirrhus lie in the comparatively large amount of fibrous material that separates the channels one from another. Hence it is that scirrhus has a hard, almost woody feel, whence the name (σκιρρος, hard).

3. Encephaloid or medullary carcinoma is distinguished from scirrhus, microscopically, by no other features than that the epithelial deposits are larger, while the connective-tissue stroma or basement substance is less in amount and more delicate in structure. It is commonly and with justice regarded as the most rapid in growth and malignant of all carcinomas. In its external manifestations it appears as an exuberant, soft, and florid fungoid mass, early exhibiting a tendency to ulceration and hæmorrhage. Its favorite seats are the liver and omentum, though the breast, uterus, and other external or internal parts are occasionally affected. The name encephaloid well describes its soft, semifluctuating characteristics, which are not so clearly indicated by the less common name medullary, a term intended to characterize its marrow-like softness. Fortunately it is one of the rarer varieties. Some authors, the Germans more especially, have described a further variety, intermediate between scirrhus and encephaloid. They call it carcinoma simplex (simple cancer). While the distinction can be sustained from the standpoint of pathological histology, it would be difficult to do so from any other aspect. (See the preceding article, on the Histology of Carcinoma.)

4. Colloid carcinoma is a very peculiar subdivision, and the most uncommon. It consists of a series of firm, hard, usually nodular, formations, made up of fibrous tissue, in which are crypts (alveoli, or loculi) filled with a peculiar opalescent colloid or gelatiniform substance. This colloid matter is derived from the transformation of epithelial bodies, which have in part been distended by the gelatinous material that destroyed them, and in part have been compressed into scales, or broken up so as to form granular débris; the cells and débris either representing concentric laminæ in each alveolus, or being nested together at its central point. The alveoli, or loculi, are nothing but the distorted and deformed lymphatic channels, and the colloid metamorphosis which they undergo indicates a destructive process that is in the direction of a cure; hence these tumors, though bulky, are slow in their growth, and the prognosis would be comparatively favorable were the whole deposit, in a given case, of the nature just described. Unfortunately this benign character is seldom very extensive, but more or less of scirrhous, and even perhaps encephaloid tissue, is apt to be present and to govern the issue of the case. And hence it is true also that colloid carcinoma might, with some degree of right, be classed rather as an incidental change in carcinomata than as a separate form of this class of tumors. It is convenient, however, from a clinical standpoint, to maintain it as one of the principal divisions of carcinoma. (See Colloid Carcinoma of the Stomach.) It is chiefly found in the gastro-intestinal tract, but may occur elsewhere, as in the breast.

* In a previous paper (Observations in One Hundred Cases of Carcinoma, by Dr. T. E. Satterthwaite and Dr. W. H. Porter, New York, 1879), cauli-flower growths were classed among the five principal divisions of carcinoma. They are here classed among the epitheliomas, for reasons that will be given in another place.

It is next our purpose to study carcinoma as affecting special organs or parts, as in this way a better conception of the disease is gained than by general statistics, which, however, will be taken up subsequently.

Epithelioma of the Face.—This variety of carcinoma is usually the flat or superficial epithelioma, and, therefore, the mildest form of all. It has little tendency to extend deeply into the tissues. Made up chiefly of cuboidal cells, it differs from the deep variety in that the latter is characterized histologically by the squamous cell-formation—at least, as soon as the disease has reached a certain grade of maturity. At this late stage the "nesting" of the epithelial cells is uniformly observed. Much confusion has, unfortunately, existed in medical minds on account of the nomenclature of this superficial epithelioma, which has varied according to the place of residence of the writer. Thus in England it is commonly known as rodent ulcer or cancer, in France as *cancroide*, in Germany as flat epithelioma. Most authors, however, at the present time, at least those who may be regarded as proper authorities, have agreed (Warren, Tilbury, Thos. Fox, and many others) that the dense infiltration of the skin is due to the presence of cells similar in character to those of the rete Malpighii, or mucous layer, and the conviction has become established that rodent ulcer is a peculiar ingrowth from the rete; one which, for some unknown reason, perhaps owing to the nature of the soil at its point of origin, exhibits less tendency to active growth than the squamous or deep variety. It seems also to select, as its special point of departure, a somewhat deeper portion of the epidermis, occasionally originating from the wall of a sebaceous gland or hair follicle, both of which may be regarded histologically as inversions of the epidermis; and yet it will not be disputed that in the later stages of rodent ulcer it may assume some of the characteristics of the deep variety, and exhibit in greater or less degree something of the peculiar "birds'-nest formation" that has already been described (Warren, Arnott). It is most likely to be mistaken for lupus vulgaris or syphilis. The points for discrimination have been thus given (Moore): "Lupus occurs in the young adult; rodent ulcer in the decline of life. Lupus is a strumous affection; rodent ulcer originates in persons previously healthy. Lupus commences as a low tuberculous elevation of the skin; rodent cancer as a firm, uncolored nodule. In lupus there may be more than one tubercle; the pimple of rodent cancer is solitary. Lupus first scales before it breaks; rodent cancer first excoriates, and then scales and bleeds. Lupus may cicatrize and heal at any time; rodent cancer proceeds with at most but a temporary and partial healing near the edge. Syphilis is rapid; rodent cancer slow. There is (in lupus) no solid border, but a sharp edge; in syphilis it is a ragged ulcer, surrounded by a violet halo of injected skin. It has no hardness or firmness."

Sometimes the flat epithelioma (rodent ulcer) will heal at one part and ulcerate at another, like the serpiginous syphilitic ulcer so well seen upon the knee; anti-syphilitic treatment should always clear up any doubt on this score.

The treatment of epithelioma of the face is simple, and consists in destroying the growth by some powerful caustic, such as arsenical paste, the terchloride of antimony in saturated solution, or the thermo-cautery. By any one of these methods, or by others of similar character, the ulcer may be quickly and satisfactorily removed, so that a smooth surface will be left after the separation of the eschar. Though a recurrence may be anticipated, the disease can still be held in check for many years. It seems doubtful if internal treatment exerts any favorable effect upon the growth. Usually the etiology of a rodent cancer is sealed in much obscurity. Of hereditary history we have no certain data, but there is no doubt that traumatisms are associated in the minds of the patients quite frequently with the origin of the disease. Thus in two cases in my experience the cause was thought to have been, in one case, the scratch of a tooth comb, and in another, the application of creasote to the face. Apart from the diagnostic points already given, it may be said that we have less to guide us in this form of carcinoma than in any of the others, so far as the microscope is concerned, for usually there is nothing in the histological characters of the growth beside the dense infiltration of the skin, or, in rarer cases, the subcutaneous tissue, with the cuboidal cells already mentioned. But the region of the face will assist us much in arriving at a diagnosis, particularly if we remember that rodent ulcer affects chiefly the upper and anterior part of the face, while the ears, nose, tongue, and lip are the chosen seats of the deeper variety. (See Plate IV., Fig. 1.)

Trustworthy statistics are wanting in reference to the average duration of this disease.

I have certainly known it to last four, five, and seven years, while in one case, in which the upper eyelid was attacked, the patient survived thirteen years, dying finally of exhaustion after four operations.

Other forms of carcinoma may attack the face, though rarely. Next in order of frequency to the two already mentioned is scirrhus.

Epithelioma of the Lip.—Carcinoma of the lip is almost invariably an epithelioma, and of the deep or squamous-celled variety, this being peculiarly true when it is situated on the lower lip. Rodent ulcer, or the cuboidal-celled epithelioma, may, it is true, attack the lip, but then it is usually the upper one; while if the former variety is found on the upper lip, it will in most instances be found to have travelled round the angle of the mouth from the lower one. Epithelioma of the lip is a disease of men rather than of women, and in the proportion of eight to one; possibly the disproportion is even greater; it prevails in the decades of past-middle life, from fifty to sixty, or from sixty to seventy, usually in the latter, though it may exceptionally originate at an earlier or later date. Statistics that are at our command appear to prove conclusively that some local irritant plays an important rôle in the etiology of lip cancer, no one cause being so frequently assigned as the smoking of a pipe. In nine out of ten cases in my experience this fact was elicited by personal inquiry, when the patient or his friends assigned any cause. In the tenth case the disease was said to have been induced by the constant chewing of a toothpick, a practice that was almost constantly pursued during working hours, the patient being superintendent of a gang of laborers. Others have enumerated the following as causes: syphilitic ulcerations, holding of twine in the mouth by packers, tasting of new wine (Cooke[5]), abrasions caused by bad teeth. There seems to be even less of hereditary tendency in lip cancer than in some others.

Usually the growth appears at the junction of the mucous membrane with the skin, and at first it may be mistaken for a pimple; soon, however, it exhibits an indurated base and begins to extend, infiltrating adjacent parts. Later on, the central portions of the tumor soften and are covered by a thin scab. Sometimes the new tissue disintegrates rapidly and ulcerates out, leaving a cavity with a dirty uneven base, and ragged, overhanging edges. There is no difficulty at this advanced stage in distinguishing this form of epithelioma from the superficial variety that we call rodent ulcer. For, in the latter, there is less infiltration of underlying parts, and the ulcer is small, secretes a very much less amount of matter, and often is covered by a thin little scab, which, when removed, reveals a slight hollow covered over by a thin sanious fluid, the edges of the growth being raised and tuberculated. This latter form of epithelioma is also very slow of growth. If it assume any of the characteristics of the deep epithelioma, it is only after years of development. The deep or squamous epithelioma sometimes appears to begin as an ulcer or as a fissure, or cleft in the skin. In such cases it is hard to distinguish it from a chancre, for in both there is induration of the base at some time or other. In syphilis, however, the ulcer soon heals, even without constitutional treatment; while if secondary symptoms have manifested themselves there is comparatively little difficulty in making the diagnosis. So far as the glandular implication is concerned, there is also this important difference, that in epithelioma the submaxillary

and sublingual glands are first attacked, while in syphilis it is the post-cervical. There should be no difficulty in differentiating eczema, psoriasis, sycosis, and other skin affections from epithelioma. They chiefly affect the upper lip. In the further progress of the malignant growth the muscles and bones are attacked, and now the patient begins to show that the system is becoming profoundly affected. Death may ensue at any time from hæmorrhage, which is always imminent when the deeper parts have become involved; or gradual exhaustion of the vital powers may induce the fatal issue. Sometimes the metastatic deposits in neighboring parts bear no relation in point of extent to the original focus of disease. The former may be most extensive, while the latter is comparatively insignificant. It is now that the patient becomes a most unhappy sufferer, chiefly from the pain that is occasioned by all efforts at mastication. Sometimes the bulky character of the growth interferes with the taking of food (see plate No. IV., Fig. 4). No treatment offers such good hope of success, as that by the knife, and it matters not whether a V-shaped or semilunar incision be practised. It is necessary only to remove the whole tumor completely. Fortunately the lip is extremely pliable, and even if a very considerable portion of it be removed, little or no deformity will ensue. Most frequently the disease returns, and in the cicatrix, sometimes in adjacent tissues, such as the glands or bone. Implication of these parts is commonly regarded as a contraindication to the performance of an extensive cutting operation. Occasionally the surgeon may find it desirable to use caustics, such as the chloride of zinc (Cooke, Purcell), pernitrate of mercury, etc. The objection to them is grounded on the danger of producing constitutional disturbance, and undue irritation. Whether or not the operations by cutting or by caustics add to longevity are questions that are difficult to answer satisfactorily at the present time, owing to the insufficient number of well-attested cases from which such points can be studied. It has been stated that after removal the disease may not return; at least an instance is given in which, after two removals, the disease ceased to recur, the patient dying at an advanced age twenty-five years after the operation (Gross[7]); others (Humphry,[8] Cooke[9]) have cited instances in which the immunity exceeded five years.

Mr. Bryant[10] gives an instance in his practice, in which an epithelioma of the lip of one year's standing was removed and did not return for two years; then after removal there was no recurrence for three years; after a third removal it did not return for four years. In another instance cited by him, the first operation secured immunity for fifteen years; a second one for eight years; and seven years after the third and last operation there were no signs of a recurrence. Usually the disease returns, and within the year; but notwithstanding this fact, there appears to be a concurrence of opinion among surgeons, as the result of their experience, that if the growth be removed early and thoroughly, the patient's expectation of life will be materially improved.

Epithelioma of the Tongue.—If a malignant neoplasm attack the tongue, it may be pretty safely set down as an epithelioma. Exceptions to this rule are at best very rare,[11] and yet we have the testimony of some excellent observers that scirrhus, encephaloid, and sarcoma may be found in this organ. There are several ways in which such statements may be viewed. Possibly the writers depended on the naked-eye appearances in the supposed cases of scirrhus or encephaloid, while in the matter of sarcoma an error may have been more easily committed from the great liability of confounding it with a syphilitic gummy tumor, a simple inflammatory deposit, or even, possibly, an actinomycetic growth, which, though an affection more common in the bovine race, has been recently shown to affect the human tongue. Though a careful microscopic examination would have positively established the diagnosis in the case of scirrhus or encephaloid, we must remember that the same rule does not apply to all sarcomas; indeed, it may not be at all possible to differentiate some of the sarcomas from syphilitic new formations without the corroborative evidence of an anti-syphilitic treatment prolonged for a suitable time. On the other hand, a diagnosis, in the case of an actinomycetic growth, can be quite easily established by the presence of the peculiar golden or lemon-yellow granules which are characteristic of the fungus (see article on this subject).

Epithelioma of the tongue is one of the most common varieties of carcinoma, usually standing fourth or fifth in point of frequency. It may originate on the surface or in the substance of the organ. In the former case it develops in or from a wart, fissure, or ulcer. The destructive process spreads at times with great rapidity; then for a while it will appear inactive, or healing will seem to set in after some sort of a fashion, so that the patient or his attendants may begin to fancy that a positive improvement is at hand; or, after the growth has attained a considerable bulk, perhaps when it has invaded the palate or tonsil, sloughing will take place, and a considerable portion of the disease will be separated. Now, if contraction of the sound tissue takes place, the sore will appear to be, and will be, smaller, so far as its apparent circumference is concerned. Then the edges will appear elevated, indurated, and, perhaps, ragged; their summits terminating in rounded tubercles, capped here and there with whitish prominences, due to the dense collections of squamous epithelial cells (see Plate IV., Fig. 3). It is at this ulcerated stage that epithelioma is most apt to be mistaken for an ulceration following the separation of a gummy tumor. But syphilitic disease is prone to be central or bilateral; epithelioma is usually unilateral. At first there is little or no discomfort to the patient, but when the muscular tissue of the organ has become infiltrated, or as soon as the glands have become involved, shooting pains attend every effort at speaking or eating. When ulceration has become extensive, the discharges of the ulcerated surface begin to be very offensive, not merely to the patient, but to all about him, and they are apt to collect in the throat, and to fall upon the glottis, giving rise to an annoying cough; or, they may find their way into the bronchial tubes, setting up bronchitis, or even a pneumonia, that is naturally of the septic type. Commonly the disease extends by contiguity to the adjacent parts, such as the pillars of the fauces, tonsil, vault of the palate, or uvula, or it may proceed in a downward direction.

Males are certainly more frequently affected than females, and Butlin[12] has found the ratio to stand as 6 to 1. It is also a disease of middle and past-middle life, occurring most frequently between the ages of forty and sixty, and more particularly between fifty and sixty. It may be regarded as doubtful whether cancer of the tongue has ever been observed under the age of twenty-nine; it is certainly rare after seventy.

It is equally well determined that a hereditary disposition has not been observed in epithelioma of the tongue, but that its origin is usually associated with some irritating cause, most commonly, as in epithelioma of the lip, with the smoking of a clay pipe, or the friction of a defective tooth or tooth-plate. In a small number of instances it appears to develop from a syphilitic sore, or from some skin affection, such as psoriasis, possibly from the peculiar disease known to English writers as chronic superficial glossitis (Clarke). From the description here given it is plain that an epithelioma ought to be satisfactorily differentiated from a gummy tumor, though I have no doubt, judging from personal experience, that the discrimination is not always made by physicians. It should be remembered that the gummy tumor usually appears as a soft, often semi-fluctuating, ovoid, or rounded tumor in the substance of the tongue; it may even occupy fully one-half of it. The iodides given in doses sufficient to produce their full physiological effect will cause such tumors to disappear with most marvellous rapidity, if destructive changes have not occurred in them; and even if the slough has separated, they will heal under the same treatment, leaving, it is true, behind them deep cicatrices with sinuous edges. But it should also be remembered that the treatment by the iodides will at first act favorably upon epithelioma. Its good effect is soon lost, however, and in a few weeks the process of ulceration or infiltra-

tion will extend as before. The implication of the glands assists much, however, in the diagnosis, for in epithelioma the hardness of the glands is like that of the hardest wood. Sometimes they might even be said to have a stony hardness. They soon become fixed in one position. Syphilitic glands are not so fixed. Of course the discovery of general syphilis assists much in the discrimination. But even a person of limited experience should not mistake ordinary mucous patches, or the opaline plaques which they leave behind them, for anything but evidences of syphilis. So, too, tubercular ulceration, nævus, or hypertrophy of the tongue need no separate description, and yet I know of an instance in which a tuberculous tongue was removed in the mistaken notion that it was epithelioma. Tubercular or scrofulous ulcerations are certainly rare, so that such errors are the more easily excused. The lips are usually attacked at the same time, but there is always the individual or hereditary history of tubercular taint. Then the sores are chronic, breaking out when the patient is for any reason below par, and healing up if he recuperates. They are superficial, have a gray, rough base, ragged edges, and sluggish aspect. There is no induration about the base.

After an epithelioma of the tongue has progressed to a certain point, violent neuralgic pains will commonly set in, owing to implication of the lingual nerve. In a few cases there are metastases to internal organs, such as the lungs, heart, or liver.

As soon as the nature of the disease has been determined, the question of the removal of the part affected should be considered at once, provided, of course, it is easily accessible and that the glands, the submaxillary and sublingual more especially, are not involved. Some form of thermo-cautery is the best instrument to use, but the knife or ligature is also available. But even if the growth cannot be extirpated *in toto*, any special source of irritation may be removed. If this cannot be accomplished, it will be advisable to make soothing applications of some anæsthetic, and at the present time cocaine, in the ordinary two per cent. solution, or menthol suspended in mucilage, or some mild alkaline wash, offers the most satisfactory means for combating the pain. If, however, it be very severe, the gustatory nerve may be cut. Mr. Barwell [13] recommends it, but only when the whole organ is involved and if the suffering is intense.

According to Clarke,[14] the operation prolongs life. Thus in twenty-five cases, in which no operation had been performed, the average duration of life from the inception of the disease was forty-two weeks; while in fourteen, in which an operation was performed, the average was eighty-six weeks. Butlin's [15] statistics, derived from the most satisfactory cases to which I have had access, give a different view of the case, though the results point in the same direction. Thus of seven cases not operated on, the average longevity was eighty-three weeks; while of twenty-five in which an operation was performed, the average was one hundred and ten weeks. Paget's figures establish the same general conclusion. But even if the operation could not be shown to prolong life, it should be advised, for the reason that the patient is rid, for the time at least, of an offensive ulcer, that produces most annoying symptoms. With these general considerations, each case of tongue cancer should be studied in the light of its special surroundings. As a rule, the nearer the growth is to the apex of the organ, the more favorable the prognosis for operative interference. When the disease is situated at or near the base, the operation is one of no little magnitude, and invites very thoughtful consideration on the part of the surgeon.

Epithelioma of the External Genitals.—1. *Male.* —A. Penis. Epithelioma appears to be the principal form of malignant disease that attacks the penis. It usually occurs between the ages of forty and sixty, chiefly in the latter half of this period, as in epithelioma of the tongue. It is rarely confounded with any other disease, although it may be mistaken for a syphilitic lesion, such as the indurated chancre, or condyloma. Epithelioma usually attacks the foreskin on its internal side, and in this regard it may be differentiated from chancre, which usually develops on the external surface. Of course the subsequent appearance of syphilitic lesions will render the diagnosis more easy if the diagnosis rest between syphilis and epithelioma. On the other hand, a condyloma being quite amenable to the internal treatment for syphilis, it can be diagnosticated in this way, especially if the history of syphilis is uncertain. It seems to be plain that at a certain period of life there is a tendency toward malignant transformation of epithelial structures, though certain conditions, chief of which appears to be some local excitant, must be present as etiological factors, else the peculiar change will not take place. Mechanical friction is the causal element to which our attention is chiefly drawn in this particular disease, and the penis that is covered with a long foreskin, behind which there is always a greater or less collection of epithelial débris or glandular excretion, is the one that presents the largest opportunities for the unfavorable change; and for the reason, also, that the epithelial coating of this part is extremely delicate, and therefore more susceptible to injury. Sometimes a congenital defect may determine the growth to the part, as in a patient of mine, in whom a pimple or wart that had remained inactive on the foreskin for forty years or more, took on malignant action at the period of life at which such tissues are most prone to malignancy.

As soon as an epithelioma of the penis shows its characteristic features, induration of the base begins to be apparent, and more or less of a sort of ligneous infiltration will be observed to spread slowly along the organ until finally the root is reached, unless its course has been intercepted by an operation. Sometimes the growth early exhibits a protuberant, fungoid appearance; but if at any time the flow of blood to the part is obstructed to a considerable extent, the nutrition of an epithelioma may be so cut off that sloughing will ensue. At first the inguinal glands will be irritated or simply inflamed by the local disease, especially if the affected part encounter any rough handling, as from a blow, etc. Later they will become infiltrated, and will then increase gradually in size during the life of the patient, unless removed by operation or reduced by ulceration or other degenerative processes.

Though epithelioma usually takes its origin from the foreskin, it also springs from the surface of the glans or from the body. In its progress the penis and scrotum may be destroyed, a fungus-like mass occupying their place. Death is usually due to the exhaustion consequent upon the drain on the system of the continued discharges, or to hæmorrhage, or both.

The proper treatment, when the disease has once been positively determined, is local excision, or amputation of the penis. The first-named operation is permissible when the growth is small and the indurated tissue can be removed by a single incision; the latter is to be preferred when the penis itself has been invaded. Though infiltration of the glans is sometimes held to be a bar to amputation, this need not be so, because even in such cases the disease may not, after amputation, return in the cicatrix, and the patient will meanwhile be rid of an offensive and painful sore. Caustics are specially contraindicated, but often sedative applications will give great relief. Unfortunately we are not in the possession of statistics as to whether operative measures in this disease offer greater chance for prolonging life than non-interference. Sibley gives thirty-four months as the duration of life after the inception of the disease, provided there has been no operation. In three cases of operation, in my tables, one died seventeen months after the disease began; another eighteen months; while the third was alive at the end of ninety-five months. The duration of life under such circumstances averages from sixteen to thirty-six months. The operation of amputation is extremely simple, as it can be most satisfactorily done by a single stroke of the knife. The hæmorrhage that follows can be easily controlled.

B. Scrotum. Epithelioma of the scrotum is of the deep or squamous variety. It originates usually as a wart upon the scrotum. In England, where it appears to have

been common among chimney-sweeps, it has been called chimney-sweep's cancer; but the same kind of irritation may cause it to grow upon other parts of the body, as the hand or wrist. Originating in this way, it may be inactive for years and then suddenly become soft, vascular, and painful. Soon a serous exudation is noticed upon the surface; then a scab forms. When the latter separates, it reveals an ulcer; the wart now is destroyed and a chronic sore results, eating into the testicle and infiltrating the inguinal glands, unless the patient die earlier of some intercurrent disease. It is rarely seen in this country.

2. FEMALE.—*A, Labia; B, Clitoris.*—Epithelioma is the form of cancer that attacks the labium and clitoris, usually the former. It appears first as a small nodule or berry-like prominence of the mucous membrane near its junction with the skin. It grows much like an epithelioma of the penis, but is more extensive, for though the disease usually begins on one side, both will eventually be involved; in which event there will be solid fungoid excrescences tipped with tubercles having rounded prominences. Ulceration, too, sets in early, leaving ulcers with worm-eaten bases, undermined edges, and induration with infiltration of surrounding parts. So extensive may this growth be, that it will often encircle the vaginal orifice, and extend to, and even implicate, the anus. The inguinal glands do not appear to be attacked very early, but perhaps it is more an apparent than a real tardiness, due to the fact that the glands are more apt to be hidden by adipose tissue in the female; though it is a fact that the female inguinal glands are less prone to exhibit constitutional infection than the same glands of the male. It is thought by some surgeons that the extension of the disease from one labium to the other is due to auto-inoculation, the diseased labium chafing the healthy one and introducing the morbific material at the point where the surface is abraded. If this be true, it is probably the only instance in which the virus proves inoculable in the human subject. Though the disease may be very extensive, it does not necessarily give much pain; but when the swollen and infiltrated tissues offer an obstacle to the passage of urine and the pent-up secretions, the distress may be very great.

Epithelioma of the labia is a disease of past-middle life, usually occurring between fifty and seventy. Instances in which this disease is said to have occurred under twenty-five should be looked upon as doubtful, unless satisfactory microscopic evidence has been furnished. In the early stages the disease may not be easily differentiated. If, however, we observe a florid granulation that grows rapidly, bleeds easily, has some induration about the base, cannot be favorably affected by specific treatment, if removed soon recurs, and is associated with swollen glands which in good time assume a woody or stony hardness, we may be pretty sure of our diagnosis. In young persons it is most apt to be confounded with a syphilitic condyloma, which often attains a large size and is an exuberant fungoid mass. Closer examination will show that the condyloma is a papillary growth, consisting of myriads of slender stalks, each surmounted by a rounded head. As further aids in arriving at a diagnosis, there are the syphilitic history, the peculiar smell, the result of treatment by anti-syphilitics, and the age of the patient; condylomata being more common in early life. (See Plate IV., Fig. 2.)

The treatment should consist in early and very thorough enucleation; and the knife or galvano-cautery, as the case may be, should cut wide of the indurated tissue. When the glands are involved, there is no special contraindication to an operation, and, indeed, though the operation may not eradicate the disease, the patient will be relieved in many ways. Sometimes palliatives only are indicated, and, to subdue the pain, ice and salt in rubber-bags may be applied, or the cold-water coil, or perhaps preparations of lead and opium, cocaine, or menthol. Disinfectants will be needed in the advanced stages, and none remove the unpleasant odors more satisfactorily than the permanganate of potash in a weak solution (ʒ j.–Oj.). The disease is usually borne from fifteen to twenty-one months, though there are instances in which the duration has been much longer—three years and possibly more.

CARCINOMA OF THE INTERNAL GENITAL ORGANS (FEMALE).—1. *Squamous Epithelioma.*—Carcinoma occurs in the uterus under five separate varieties, each possessing certain peculiar characteristics, though they are not all equally distinctive. First in point of frequency comes scirrhus; then there are the medullary and colloid varieties; next the ordinary squamous epithelioma, and lastly the cylindrical epithelioma, or cauliflower excrescence. (See Scirrhous Carcinoma of the Uterus.)

The ordinary squamous epithelioma originates in the cervix, from which it gradually extends through to the body and fundus, rarely if ever spreading in a reverse order. It is usually observed about the climacteric period, the patient first experiencing slight pain or distress in the pelvis. Perhaps there is a little leucorrhœa. Commonly these phenomena do not attract much attention, and it is only when a sudden hæmorrhage from the vagina takes place that serious alarm is felt. And yet by this time the disease will probably have attained considerable bulk, so that the finger can appreciate the tuberculated and ulcerated surface. Still this manipulation may not occasion much pain, or even a decidedly unpleasant sensation. There will now be a continuous discharge of thin, watery, offensive, and at times discolored, fluid. Other hæmorrhages may now occur at any time. The uterus will still remain freely movable. But constitutional symptoms, as evinced by emaciation, pallor, disordered appetite, and fever will gradually develop. Later on pain will be more prominent as a symptom, and it may be sharp and stinging, or dull and heavy.

As the discharge increases in amount, the vagina and external genitals will become excoriated, possibly also the adjacent skin. In time micturition and defecation may be interfered with. Death may be due to exhaustion, peritonitis, or hæmorrhage. In order to distinguish between this variety of epithelioma and scirrhus, the diagnostic points to be mainly considered are those common to both, such as the age of the patient, the hæmorrhages, offensive discharges, the emaciation, cachexia, and such gross changes as may be appreciated by the finger; while the characteristic differences are that in epithelioma of the os (squamous variety) there is, for a considerable time at least, no fixation of the organ, which even in later stages can be moved about without occasioning pain or sensitiveness, while in many instances, owing to the extensive ulceration of adjacent parts, it may be moved about even more easily than the healthy uterus. In scirrhus there is extensive generalization of the disease; in epithelioma it rarely spreads beyond the nearest chain of lymphatic glands, except by continuity. The nodular edges of the ulceration and the offensive discharges distinguish this form of epithelioma from an ordinary ulceration, while in the cervix of a uterus that has been lacerated by any of the accidents attendant upon pregnancy, the induration due to cicatrices is not hard as in epithelioma.

Treatment should consist in excising as much of the os as is diseased, and with it a broad zone of the normal contiguous tissue; or, if that be impracticable, in extirpation of the growth with the actual or galvano-cautery. When operative procedures are not admissible, either from the extent of the tissues involved, or from opposition on the patient's part, local sedatives are employed with good effect; of these carbolic acid in solution may be useful, both for its anæsthetic, disinfectant, and healing properties. In the proportion of one to twelve in glycerine it may be advantageously applied to the diseased parts. Tampons of absorbent lint may also be very necessary; cocaine and menthol are also proper remedies. The vagina should be frequently washed out, while occasional laxatives will be needed to keep the fæces soft. In the last stages of the disease opiates may be required, and oftentimes they should be administered continuously, as otherwise the pain would be insupportable.

2. CYLINDRICAL EPITHELIOMA (*Cauliflower Excrescence.*—Accepting the tendency of the present time to rank this growth among the epitheliomas, I have placed

it among them rather than as one of the five great subdivisions of carcinoma.

Originating either from the os or from the uterine cavity, it first appears as a highly vascular, flesh-colored tumor, which bleeds readily on pressure, and from whose surface exudes an abundant watery fluid. (See Plate IV., Fig. 5.) It is an exuberant, soft, spongy growth, that soon becomes bulky if not interfered with by operation.

Microscopically it is seen to consist of a collection of elongated papilla interconnected with one another, each separate papilla consisting of a delicate stalk, in which is a vascular loop, while the surface is covered by long cylindrical epithelial cells. From a microscopic point of view a differentiation of the neoplasm is simple, as it can only be confounded with a benign papilloma (warty growth). But as these latter never become bulky there is no difficulty in forming the diagnosis as soon as the cylindrical epithelioma attains any bulk. This it does at a comparatively early period, and then the other attendant phenomena of carcinoma are present to assist in the diagnosis.

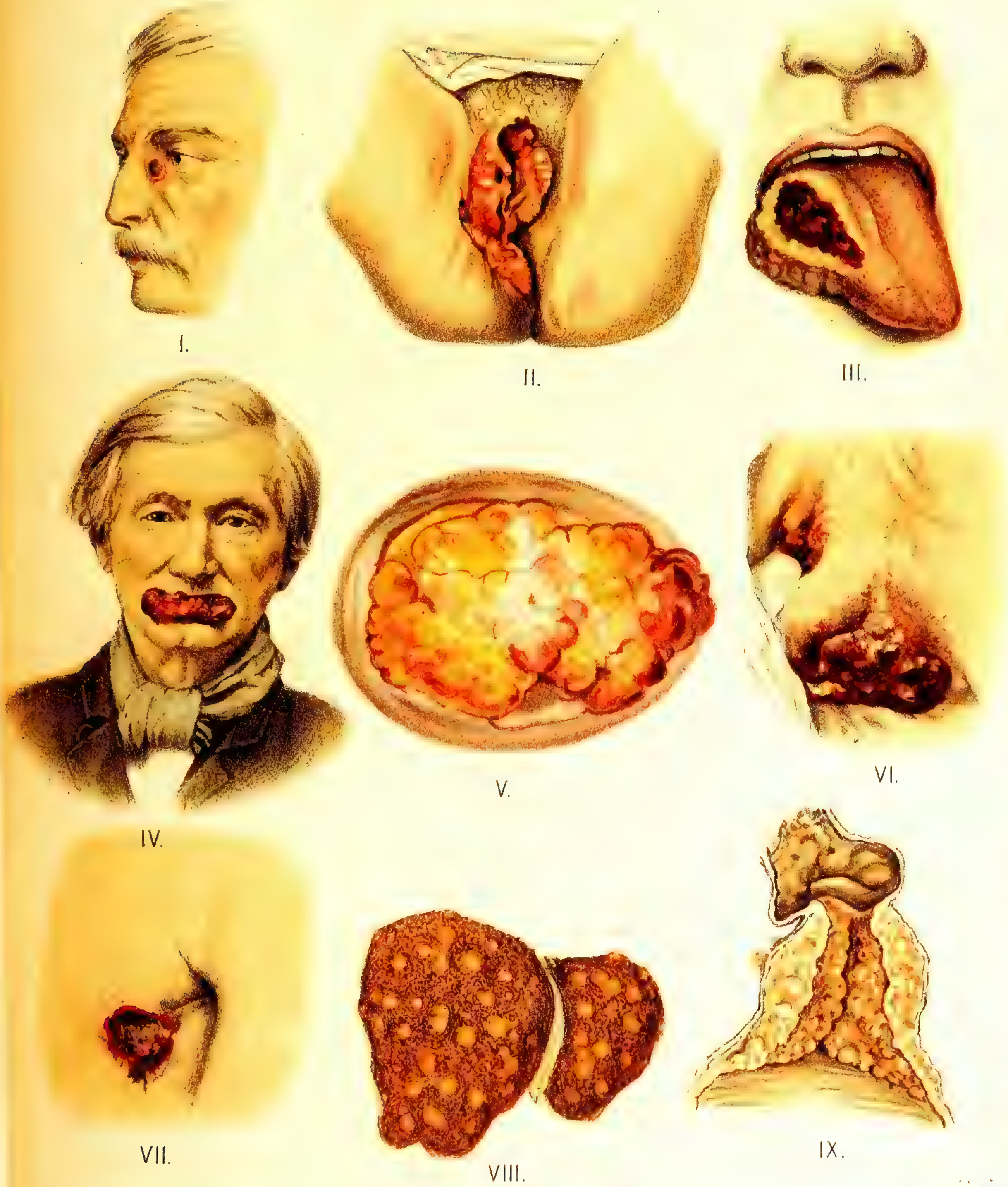
There is then a profuse watery discharge, now and then intermixed with blood, which is especiably noticeable after sexual intercourse, digital examination, or movements from the bowel. And yet the patient may not complain of pain, partly because so much of the growth is external to the organ from which it springs. Indeed, although the vagina may be filled and the proliferating mass extend beyond the external genitals the prognosis is comparatively favorable for an operation. At first local astringents have a good effect, not only checking the watery discharge, but even diminishing the size of the tumor. Chief among them are the vegetable astringents, of which the best example is tannic acid. If more active measures are indicated a ligature may be applied, and the growth can then be removed, or even if it recur, as may be anticipated, the same astringents can be used effectively to retard its subsequent development. Local irritation of any sort must be rigidly avoided.

The cause of this variety of carcinoma, as of all the others, must be referred to the vicissitudes which the organ experiences through its periodic activity, either at the menstrual or child-bearing period; to the various functional disorders which it experiences, and to the mechanical abuse to which it is subjected during sexual intercourse. There seems to be very slender ground for attributing carcinoma to nervous disturbance. In the last stages of carcinoma of the uterus there are strong clinical resemblances between the several varieties, and indeed there is no great difference in the treatment that is applicable to them severally.

Carcinoma of the Stomach.—The stomach is frequently the site of carcinoma, and especially of the scirrhous form; indeed, in this respect the organ holds second place with some authors. It usually makes its attack between the ages of fifty and sixty, although it has been noted at as early an age as twenty-six, and as late as seventy-four. The origin of the growth may most frequently be traced to the submucous layer of the stomach and to the glands of that part. More rarely it occurs as a secondary deposit, the primary disease being located in the head of the pancreas, possibly in the omentum. The colloid and encephaloid varieties of carcinoma are encountered in the stomach much more rarely than scirrhus, and the encephaloid form even less frequently. Cancer usually attacks the pylorus; but the cardiac extremity and greater and lesser curvatures are also selected. It is noteworthy but natural, in view of the physiological functions of this organ, that there should be manifest differences in the train of symptoms and their severity, according as one or another site is involved. Thus a very small amount of disease at the pyloric, or less at the cardiac orifice, may soon bring about a fatal issue; while in the greater curvature, and more especially in the lesser, a tumor the size of an orange may give comparatively few symptoms and not endanger life for a long period. And, perhaps, which is even more astonishing, the entire organ may be infiltrated with cancerous deposits throughout its entire extent, and yet perform its duties successfully for a longer period than when either of the orifices is involved. The explanation of this is probably to be found in the facts that as the centres of disease are distributed symmetrically throughout the organ, the localized contractions which take place at a later stage are also symmetrically distributed, and that, finally, while the organ may be so reduced in size that it cannot hold more than a pint, there is no bar to the progress of food, but merely an abolition of stomach digestion, from the derangement of its epithelial tissues and the unyielding character of the gastric walls.

When scirrhus occurs at its favorite seat, in the pylorus, it is at first observed to be a small, flattened, and circumscribed tumefaction; as it develops, the mucous membrane, on the one hand, and the muscular substance on the other, are encroached upon; when the latter is invaded it is at first thickened by the new deposit, but subsequently the muscle substance is absorbed and replaced by the cancerous material. The mucous membrane is affected in various ways. Sometimes its papillary layer proliferates extensively, so as to be covered by numerous fungoid growths, which in the progress of the disease slough off, leaving an excavated ulcer with an indurated border and base. While this growth is developing, hæmorrhages may at any time occur from the rupture of the minute vessels that grow in the papillary tufts; or if sloughing has set in and an ulcer has been left the extension of the disease may at any time cause erosion of a vessel and hæmorrhage from this source. At times the mucous membrane will suffer little change. At the inception of the disease there is apt to be a sense of uneasiness, perhaps at times a dull pain over the organ, especially if the disease is situated at either orifice; when the pylorus is the part involved there is some distress after eating, usually after food has lain some hours in the stomach. The patient then believes himself the subject of an aggravated type of dyspepsia, as judged by his loss of appetite, flatulence, sour eructations, and relief after belching of wind. As the disease progresses these symptoms become more pronounced. Sooner or later emaciation sets in, and there is more or less disturbance of the mind; but there is no fever or increase in the frequency of the pulse. The greatest distress is felt when, after having eaten, fermentation takes place. There is then nausea, but no relief comes until the stomach has been emptied. Then a period supervenes when there is no pain of any description, but merely the exhaustion consequent upon the efforts to produce vomiting. When the tumor is located in the greater curvature the nausea and vomiting occur, as a rule, soon after eating, while hæmorrhages are apt to be frequent and copious, the vomited blood having a dark red or more often a brownish color, like that of coffee-grounds. If, however, the disease is situated at the cardiac extremity, we have to deal with what is practically a stenosis of the œsophagus, and it is then the act of swallowing that gives distress and pain which shoots through to the back; finally there is regurgitation of food. In disease of the pylorus we have to deal with infrequent passages, alternating with diarrhœas. When the pylorus permits nothing to pass, constipation is a necessary sequence, but if at length some of the fermented material manages to get through, its irritative action sets up a diarrhœa, and we frequently find tarry passages, partly the result of the irritative diarrhœa, and partly due to decomposed blood from the stomach.

It is not always easy to determine whether a tumor be present, even after the disease has lasted some months, and this is plainly shown by the comparatively large number of persons who have died with cancer of the stomach and yet who have given few or no indications of it during life. A considerable tumor in the lesser curvature, or at the cardiac extremity, cannot with certainty be detected. A moderately large tumor in the greater curvature may easily escape diagnosis; but a small amount of thickening at the pylorus, even if it be no larger than an English walnut, may commonly be felt, in a thin person. In the majority of cases no diagnosis is made until the growth is the size of one's clenched fist. To facilitate a diagnosis the patient should first lie upon his back, with the shoulders raised; then, after a deep expiration, the epigastrium will fall in to some extent, and the hand



TYPES OF CARCINOMA.

I. Rodent Ulcer of the Face. II. Squamous Epithelioma of the Vulva.
III. Squamous Epithelioma of the Tongue. IV. Squamous Epithelioma of the Lip.
V. Cylindrical Epithelioma of the Cervix Uteri. VI. Scirrhus of the Female Breast.
VII. Scirrhus of the Male Breast. VIII. Medullary Carcinoma of the Liver.
IX. Colloid Carcinoma of the Stomach.

can feel the pylorus, and can sometimes detect a tumefaction in the lower border of the stomach. But what is often fully as important, nodules in the liver or below the pylorus can be felt, and in the great majority of instances they suggest, through their presence, a primary affection of the stomach. Sometimes it is well for the patient to stand up and lean over; in such a position the tumor is thrown against the anterior wall of the abdominal cavity, and thus may be felt. An excessively dilated stomach will offer corroborative evidence of pyloric disease, because behind the stricture the organ is pretty generally hypertrophied and dilated. But it is a curious fact that in stomach disease, the tumor which is usually taken for the thickened pylorus is, in reality, the left lobe of the liver or a part of it which has been infiltrated and hardened by the cancer, and, after forming an attachment to the stomach, has been drawn over it by the contraction of the new growth. There are no rules by which we may, at the bedside, diagnosticate scirrhus from any other malignant tumor. This, however, may be said in favor of a differential diagnosis: In the first place, carcinoma is the only malignant growth that attacks the organ, and of its three varieties the choice lies between scirrhus and colloid, the medullary variety* being too rare to be taken into account. Colloid carcinoma is a gelatiniform infiltration of the tissue; it forms a bulky tumor, scirrhus a circumscribed one. Its relative frequency, in comparison with scirrhus, is as eighteen to one. Colloid usually originates at the pylorus (see Plate IV., Fig. 9), but rapidly extends toward the cardiac extremity. At first it spreads by contiguity, but later by metastasis, to adjacent parts, such as the omentum, mesentery, and lymphatic glands, diaphragm, spleen, intestines, and liver. Pressure is consequently brought to bear in some cases upon the portal vessels, causing ascites. Such cases will even sometimes simulate abdominal aneurism. Colloid is the most chronic form. Scirrhus rarely develops ascites to any extent. Patients with colloid may live for months or years, and the symptoms will not manifest themselves until a few weeks before death; or the patients may die without having enabled the physician to perfect his diagnosis. In my personal experience patients die in from three to nine months after the disease has been detected.

If obstruction exists, the treatment of gastric carcinoma should consist, in the first place, of excluding solid food from the regimen, and selecting only that which is nourishing and digestible. Sometimes a milk diet is well borne; sometimes the koumiss that is manufactured in our large cities, or one or other of the baby foods that are in use, with meat-broths, soups, or liquid extracts. After the patient has tried all such nutritious substances in conjunction with alkalies and preparations of pepsine, and the stomach will no longer endure anything, the rectum may be safely resorted to. Nutrient enemas will sustain life for many months (see Alimentation, Rectal).

Toward the end sedatives may have to be employed, and of these conium, codeia, and belladonna have given most satisfaction. Operative interference, such as Billroth has instituted, has not yet received the sanction of our best surgeons, though it has occasionally been resorted to.

Scirrhous Carcinoma of the Breast.—This disease springs from some point in the secretory or excretory tissue of the breast, usually from the glandular epithelium of the follicles. As it extends the fibrous framework of the organ is infiltrated and finally supplanted in great measure. For after the new cell-elements have accumulated in the follicles, they break through their walls and immediately ramify through the connective-tissue spaces, which are, in fact, the lymphatic channels. Through these media they invade all contiguous parts. Most commonly scirrhus of the breast advances toward the skin, which it absorbs and in part replaces. Should the nipple fall within the influence of the disease, it will be retracted by the contraction of the scirrhous tissue; otherwise it will not be affected in any way. If the disease spreads backward to the bones of the thorax the process is substantially the same.

Scirrhous tumors of the breast are not often bulky, because the fibrous tissue which they contain, and which constitutes their peculiar characteristic, undergoes soon after its deposition, the contraction just alluded to; hence the puckered surface of the skin when that is involved. These two points are properly held to have very important diagnostic value, and often enable the surgeon at first sight to make a rapid and correct diagnosis. No such characteristics belong to encephaloid, adenoma, sarcoma, or any benign tumors of the breast, the gumma alone excepted. Scirrhus, as its name implies, is hard to the feel; the only other growth that has this peculiar feature being colloid; but this latter is extremely rare, and in fact a curiosity in this situation.

At first, scirrhus of the breast occasions the patient little pain, but as the growth develops she complains of sharp, stinging sensations, less often of positive distress. Sooner or later the lymphatic axillary glands will be involved, sometimes the supraclavicular chain, occasionally those which accompany the internal mammary into the thorax. When the disease is superficial the axillary glands are apt to be involved; when deep-seated, the supraclavicular. Implication of these latter is thought to be an unfavorable sign, denoting that the disease will affect vital parts with unusual rapidity.

In accordance with certain gross characters observed in the different forms of scirrhus, writers have formed various classifications. Thus, Velpeau has described several kinds of *ligneous* scirrhus, and the word *lardaceous* has been used (Marsden) to indicate that the tumor has decided fatty qualities; others have used the words "globular," "radiated," "cavernous," to express properties which they have thought worthy of note. There seems to be no advantage, clinical or otherwise, in maintaining such distinctions as are here alluded to; for at the outset the neoplasm is "globular;" in spreading it becomes "radiated;" if the individual chance to be fleshy it is "lardaceous;" while it always has a "ligneous" or "woody" feel. There is but one form of scirrhus, microscopically speaking, though by the term *carcinoma simplex*, which enters into the phraseology of some German writers, is meant a growth, the intimate structure of which is such as would lead one to place it in the border-land between scirrhus and medullary. The more important clinical divisions of scirrhus will be alluded to later.

In my experience (sixty-three cases), scirrhus attacks the breast between the ages of thirty-two and seventy-five, most often between forty and fifty. Purcell places the average age at between thirty-five and fifty-five. It is the most common form of any variety of carcinoma, constituting about one-half of all varieties combined. Medullary carcinoma occurs in hardly one per cent. (Cooke says two per cent.) of the cases. The male breast is occasionally, though rarely, attacked (see Plate IV., Fig. 7).

In investigating the etiology of mammary carcinoma, we should remember, in the first place, that the mammæ are peculiarly subject to functional disturbance and mechanical abuse. Thus, in infancy and again at puberty there are peculiar affections of the nipple. Besides, at each menstrual epoch there is more or less sympathetic tenderness of the breasts, while during lactation they suffer still more from the troubles incidental to their physiological activity. Furthermore the lymphatics of the breast, which, as we have seen, are the avenues by which cancer pursues its paths, are often painful and swollen from slight causes. If we add to these possible causal factors the mechanical injuries to which the breasts are liable, owing to their prominent position and the unnatural pressure brought to bear upon them by modern methods of dress, it is easy to realize that if alteration of normal tissue or function predispose to, or occasion carcinoma, the female breasts should certainly be the organs selected for an attack. In twelve of my cases the following causes were given: In 4, a fall, in which the breast was injured; in 1, friction against a wash-board; in 1, a "buck" from a

* Sometimes in a carcinoma of the stomach small portions may appear, on a microscopic examination, to be encephaloid or medullary; but the naming of the special variety in any case depends upon the prevailing features of the tumor taken as a whole rather than upon the character of any particular part.

cow; in 1, a slight blow; in 1, a scratch; in 1, tight corsets; in 1, the application of an irritating salve; in 1, suspension of the breast; in 1, an injury of some sort not described.

Cancer is a disease of the robust, rather than of those who have had previously poor health. This is abundantly shown by statistics. And the better the previous health, the more rapidly fatal is the disease apt to be; in the feeble and old it progresses slowly.

There are some forms of scirrhus of the breast that have special clinical characters. Among them is the cuirass-formed, in which the skin is extensively involved, so that the growth is pinned down to the bones (*en cuirasse*, Velpeau). It is less malignant than the ordinary form because of the great preponderance of fibrous tissue, which causes its epithelial elements to be compressed and so retarded in their proliferative action; in fact, the excess of fibrous deposit is sometimes so great that spontaneous cures are occasionally effected by this means. In some instances this form of cancer extends to the other breast, and even around to the back, when its resemblance to a cuirass is best exemplified. The distribution of the malignant deposit in this variety is often irregular, consisting of a broad field of nodular formations varying in size. There is another variety similar in its comparatively benignant tendency to the cuirass-formed; it is known as the *atrophic*. It is of cartilaginous hardness, contains few epithelial elements, tends to spontaneous cure without the surgeon's aid, through its own preponderating fibrous substance, but it is smaller than the one just described. Almost any sort of scirrhus may be *cystic*, that is, may contain one or more cavities or loculi filled with transparent or bloody serum, or mucoid substance. Such cysts may be developed from the blocking up of glandular passages or from similar changes in the lymphatic channels (connective-tissue interstices). They are sometimes mistaken for sarcomas or mammary abscesses. In the cystic form there is apt to be sloughing, which is to be regarded as a favorable indication. When a section is made with the knife through a scirrhous carcinoma its cut surface is characteristic. It has been said to look like a potato freshly cut, but this does not describe it satisfactorily. The surface of section diminishes in size, owing to the sudden retraction of the fibrous substance, which has an opalescent, shining, bluish-white appearance, the epithelial deposits being scattered about, under the form of yellowish-white, roundish dots or streaks. When such a scirrhus has well advanced toward maturity an area of softening will be found at the centre, and if at any time the scirrhous tissue be vigorously squeezed by the hand, it will exude "cancer-juice," a yellowish-white milk-like fluid, containing epithelial and pus-cells, suspended in a liquid medium.

The treatment that has been sanctioned by practice and experience is that of early enucleation by the knife, for it appears to have been satisfactorily demonstrated that with early, thorough, and frequent removals of primary and recurrent growths, there is the best expectation of life. This statement is certainly not universally held to be true. Thus Walshe, in his able work, makes it appear that operation in cancer does not prolong life, and even Sir James Paget gives forty-three months as the average in persons who have survived the operation, and fifty-five months as the average in those who have not been operated on. On the other hand, Mr Sibley says that fifty-three is the average number of months in those who have been operated on, and thirty-two and a half for those who have gone without operation. It is rare at the present day to find patients with cancer of the breast who have not submitted to an operation, and consequently it is difficult to determine the average of life in such cases, especially as in them there would be less opportunity of securing the requisite microscopic evidence. In my personal experience I have a record of eight patients, still alive at last accounts, who had been operated upon one or more times, and who have lived a period of from seven to thirteen years from the inception of the disease. This is probably an uncommon experience, for Cooke in his statistics, derived from the London Cancer Hospital between 1851 and 1863, in a list of four hundred and thirteen patients who had been operated on, had not met with four in whom the disease had been held in abeyance for ten years; in one, however, seventeen years had elapsed. Usually the disease returns after six or seven months (Cooke).

The cause of death is usually attributable to gradual exhaustion from excessive pain, or from the drain of the constant discharges upon the system; or it may be due to the fact that the growth, by its extension, embarrasses important parts that are necessary to sustain life, such as the lungs, liver, or nervous apparatus. Thus the secondary deposits in the thoracic cavity may cause death by the septic character of the suppuration which they set up, or because they interfere mechanically with the proper oxygenation of the blood by diminishing the respiratory capacity of the lungs; or the heart may be secondarily embarrassed thereby, or directly by the pressure upon it of the new growths. In corroboration of this view, pulmonary œdema is put down as a frequent cause of death. Internal hæmorrhage is less common.

Scirrhous Carcinoma of the Uterus.—During the development of a cancerous tumor of the uterus the signs are not distinctive, for the patient may not experience any marked pain or uneasiness, though there may be occasional sensitiveness in the pelvic region, either when the uterus or its annexa are pressed upon from without, or per vaginam. Ballottement, however, or sexual intercourse may cause decided pain, and even some hæmorrhage, and there may be disturbance of the functions of the bladder and rectum. The menses are not necessarily disturbed, and there may not be any constant discharge. The system will not at first indicate that it is in any way affected by the local mischief. Still at this time a vaginal examination will often discover that the cervix is indurated or enlarged, and an examination with the speculum will demonstrate that the os has a deep purplish hue, is enlarged and nodular, and yet the organ may be freely movable, when palpation is practised. At a later period the enlarged organ will tend to fall low in the pelvis, and there is the customary uneasiness felt by the patient when in the standing position. There is now pain, or uneasiness and urgency, in urination and defecation. Hæmorrhages are now sudden and excessive. The uterus is not so movable, and softening has begun at some point or other in the organ. At length the pains increase in severity, and extend from the organ to the back and down the thighs. Sometimes they are periodic, lasting a few minutes or a few hours, and may simulate sciatic or crural rheumatism. As soon as ulceration takes place, there is more or less hæmorrhage, or at least fetid discharge, which is variously colored and which excoriates the vagina and even the external skin. The disease will now advance either to the rectum or bladder, or to both. In association with these septic discharges there will be some fever, night-sweats, and an irritable pulse. The patient's skin becomes yellow and dry, and she emaciates; the appetite diminishes, and she gradually but slowly approaches the fatal termination. The disease may now extend until a fungoid mass projects from the external genitals, or it may slough away as it forms. The average duration of uterine cancer is twenty months (Purcell), though patients may endure it five and more years.

The treatment resolves itself into the symptomatic and the radical. Hæmorrhages may be treated by astringents and ice; septicæmia by antiseptic injections; constitutional depression by chalybeates and arsenic. Usually an operation will not be admissible, simply because the surgeon does not see the patient until the disease is too far advanced. In the early stage removal of the growth will give great relief, even if it does not cure. The knife or the galvano-cautery should be used. In the last stages sedatives and narcotics, or anæsthetics, will have to be employed, and freely enough, to relieve the pain completely.

Carcinoma of the Intestines.—There is reason to believe that carcinoma may occur at any part of the intestinal tract, but it usually elects by preference the large

intestine and its inferior portion. As in other varieties of cancer, the disease is most apt to occur in late middle life, and the sexes are equally prone to it.

Carcinoma of the rectum may be either scirrhous, colloid, medullary, or epithelial, but it is probable that the squamous-celled epitheliomas originate from the junction of skin and mucous membrane, while the cylindrical-celled epitheliomas are the variety found higher up. In other portions of the intestine the variety is usually scirrhous or colloid; possibly none but these varieties occurs there.

When carcinoma originates in the rectum, the patient experiences at first a sense of weight in the back, and discomfort when going to stool, while the actual passage of fæcal matter gives some uneasiness; after a time these unpleasant symptoms increase, so that there is actual pain, especially when the movements are constipated; then tenesmus is apt to follow, and after a while blood will appear in the passages. When the disease has progressed to this point, there will be some constitutional disturbance, chiefly shown by loss of appetite and nausea.

If, now, a physical examination be made by the finger, it will be found that the gut is strictured, usually from one to three inches above the anus. After a while nodules will appear beneath the adjacent mucous membrane, and the intestine above will be distended and hypertrophied. Unless relief be afforded by some surgical procedure, the bowel will become more distended and thickened and tender, and the nausea will increase until nothing can be kept in the stomach. Possibly rupture may now take place and a fistula be established; or the contents of the bowels being discharged into the peritoneal cavity, a fatal peritonitis will ensue; or the growth may extend into the bladder or other adjacent parts, interfering with their functions and leading thereby to a fatal issue; or the patient may die from the exhausting effects of hæmorrhage, suppuration, or septicæmia.

The duration of the disease is a variable one, as death may be induced by a variety of unexpected circumstances, but usually it does not average more than twelve months. When we have cases on record of a longer duration than two to three years, it is probable that the carcinoma has been engrafted on a benign tumor, such as a hæmorrhoid. A case of carcinoma, in my experience, in which the patient is described as having had the disease thirteen years, should perhaps be regarded as an example of malignancy engrafted at a late period upon a rectal pile.

Carcinoma of the colon is characterized by some of the same symptoms as have been just described, such as pain in defecation, tenesmus, and progressive emaciation, with constitutional depression; but "pipe-stem" movements will be pathognomonic evidence, provided the seat of the disease cannot be reached by the finger introduced into the rectum. Enlargement of the lymphatic glands can rarely be detected during life.

In carcinoma of the small intestine, the symptoms are often much like those of gastric cancer. There is abdominal pain, vomiting of blood or coffee-ground material, and reddish, blackish, brownish, or greenish stools. The mesenteric glands are involved, but it is seldom that the enlargement can be detected through the abdominal walls. (See Disorders of the Intestine.)

In the early stages treatment should be directed toward securing liquid movements, and this object should be attained by suitable alimentation, rather than by the use of laxatives, purgatives, or enemas. Milk, broths, essences, fruit, and especially oleaginous matters will usually be well borne; but as soon as the diagnosis is thoroughly established, lumbar colotomy should be advised, for, if successfully performed, it will materially lengthen life and add greatly to personal comfort. In other cases the use of the solid bougie should be resorted to several times a week. Extirpation of the diseased mass by the knife or galvano-cautery is an operation that may very properly be performed, especially after the opening in the lumbar region has been well established.

Carcinoma of the Testicle.—This disease must certainly be a very uncommon one, for in the three hundred cases of carcinoma in my tables it does not once occur. In this respect it resembles malignant disease of the eye, for while the older writers tell us that carcinoma, in both localities, is comparatively frequent, the later ones do not accept this opinion, or do it with hesitation. It seems to be generally affirmed that but two forms of carcinoma, viz., scirrhous and encephaloid, affect this organ, and of those who hold to this view, some have had no personal experience with relation to the former (Butlin, Cooke). To the foreign writers, and especially the continental, we have to turn for the clinical history of such cases, and from their data, much of which cannot be regarded as thoroughly satisfactory, our present statement is made.

The disease may occur at any period, from early childhood to advanced old age, but the third decade of life is the period at which the disease is most prone to take its origin. Next in frequency is the fourth decade.

So far as it now appears, hereditary influence has not been recognized in the etiology of this variety of carcinoma, but in a certain proportion of cases, probably about twenty per cent., its origin has been ascribed to an injury; but at any rate the growth is at first insignificant, and attracts little attention until pain sets in. After the tumor has grown to a considerable size the cord will be involved in a certain proportion of cases, and thus the disease will extend into the lymphatic glands of the pelvis and abdomen and inguinal region. This complication has been noticed in about twenty-five per cent. of the cases. In a small number the scrotum will become adherent and a fungus-like mass will protrude, but it is not disposed to suppurate externally, though, as in encephaloid elsewhere, it will soften and become caseous in places.

As regards the diagnosis, the problem is usually to distinguish between carcinoma and sarcoma. Here, however, the difficulties encountered are almost insurmountable. In both forms of new-growth there is no difference in the conformation of the tumor, and, contrary to the general rule, glandular implication is more common in sarcoma than in carcinoma. In both the cord is thickened, and in both the mass may adhere to and perforate the scrotum. In fact, it must be confessed that in most cases the surgeon cannot make the diagnosis before operation. The microscope is needed to render the determination final. But we have less difficulty in distinguishing either of these forms of disease from chronic orchitis, which, being syphilitic most frequently, will usually be detected by its yielding under a vigorous syphilitic regimen. So, too, in hydrocele, there is the translucency of the scrotal fluid, the pyriform shape of the tumor, and the fact that the cord is not involved; while in hæmatocele we shall be aided by the history of an injury, and in chronic tuberculosis by the presence in most cases of general tuberculosis. (See Diseases of the Testicle.) Sometimes a diagnosis can be made by exclusion, as where the tumor occurs in a child, and cartilaginous deposits are felt by the finger. If in such an instance there is a tendency to malignancy the disease is a sarcoma.

The treatment according to present data is decidedly in the direction of an operation, especially if the cord be not involved and the glands are free; for the average duration in the operated cases (taking out of account those in which the fatality was dependent on the operation itself) has been between twenty-eight and twenty-nine months, while in the only case in which the operation was not performed the duration of life was only eighteen months. Recurrences take place in the stump, or in the lungs, liver, or omentum.

Carcinoma, when occurring in the lungs, liver, or bones, is usually secondary to disease elsewhere, and therefore has comparatively little clinical importance. (See Diseases of these organs.)

General Statistics of Carcinoma.*—1. *Epithelioma.* —Of 94 cases all but one occurred in parts of the body

* The following statistics were compiled from my records of hospital, laboratory, and private work, by Dr. J. C. Bailey, House Physician of the New York Post-graduate Hospital. They are derived from 300 cases. The frequency of the several varieties was as follows: Scirrhus, 60 per cent.; epithelioma, 33 per cent., or, including cauliflower growths, 34 per cent.; medullary or encephaloid, 4 per cent.; colloid, 2 per cent.

where they where within easy reach of operative interference, the single exception being an epithelioma of the œsophagus.

(*a*) Age. In most cases the disease appeared between the ages of sixty-two and sixty-six. The earliest appearance was at twenty-seven; the latest at seventy-eight. Winiwarter [16] puts the time when skin cancers (epitheliomas) most frequently occur, at the ages between forty-six and fifty. The statistics are tabulated with reference to rodent ulcer and squamous epithelioma, but do not include cylindrical epithelioma. For more specific information on this head the reader is referred to the clinical history of each separate variety.

(*b*) Sex. Of 79 cases in which the sex was noted, 52 or 66 per cent. occurred in males; 27 or 34 per cent. in females. It will be observed that this disproportion in favor of males is shown more positively by Mr. Paget, who found that in the parts common to both sexes, epithelioma represented a frequency of 82 per cent. in men against 18 per cent. in women. These ratios are reversed in scirrhus.

(*c*) Locality. In point of frequency the lip was the chosen seat in about 25 per cent., the face in about 12 per cent.; other parts in the order of comparative frequency here given, viz.: the tongue, 6 per cent.; the penis, 5 per cent., the jaw, labium, hand, cheek, nose, each 4 per cent.; the foot, larynx, each 3 per cent.; the axillary glands, rectum, palate, mouth, œsophagus, ear, each 2 per cent.; back, inferior maxilla, eyebrow, anus, eyelid, forehead, neck, lower jaw, and cornea, each 1 per cent.; unclassified, 5 per cent.

(*d*) Cause. In a majority of cases there had been a previous traumatism (20 out of 37, or 54 per cent.), as far as inquiry could elicit anything. Mr. Paget found that in 34 cases there had been an injury or previous morbid condition in 19 (56 per cent.). Winiwarter has enumerated as causes, slight frostings, as of the face, cuts in shaving, excoriation of the lip by pipe-smoking; burning by nitrate of silver, etc.; lacerated or incised wounds, blows, erysipelas, hypertrophy of papillary growths, acute inflammation leaving chronic infiltration, ulcerations of the skin.

(*e*) Family history. In 5 cases, or 14 per cent., there was a family history of cancer, and yet it could not be determined in this small number whether the disease was positively carcinoma; it could simply be said that it was malignant. In Mr. Paget's cases of epithelial cancer only 5 per cent. had a possible history of cancer; in something under 1 per cent. only was it known to have been epithelial.

(*f*) Pain. In a little over 41 per cent. of the cases severe pain was felt; in about 20 per cent. it was moderate in amount; in 27 per cent. there was none at all. In only 12 per cent. could no information be gained of the matter. Pain may, therefore, be regarded as an important characteristic of epithelioma.

(*g*) Implication of adjacent glands. Statistics prove little in this regard, for although in about 45 per cent. no affection of glands was noted, the matter is capable of explanation: First, In rodent ulcer, classed here under the epitheliomas, there is usually no glandular enlargement, certainly not until late in the life-history of the ulcer, and of such later manifestations there is no account; and second, because even in the squamous epitheliomas many were seen only before the period at which the glands would naturally be affected.

It may be stated as an axiom, however, that if the ordinary, *i.e.*, deep or squamous, epithelioma progresses to full maturity, the contiguous glands will quite surely be implicated. But the rate of development in an epithelioma depends on several circumstances, chief of which is the locality from which it springs, so that in some places glandular implication ensues sooner than in others. Mr. Paget found the glands involved in about 50 per cent. of his ordinary hospital and private cases.

(*h*) General health prior to the development of the disease. So far as could be learned, in 75 per cent. the previous health of the patient had been good. Whenever this was not true, the patient had suffered from dyspepsia, hemiplegia, the opium habit, hæmorrhoids, urethral stricture, alcoholism, or syphilis, or the patient's health was described as "poor." No mention was made of phthisis. These results agree with those of Mr. Paget, who states that "the general health of patients with epithelioma is usually good till it is affected by the consequences of the local disease." [17]

(*i*) Effect of operative procedures on pain. Entire relief was obtained by the cutting operation in 63 per cent., while in 7 per cent. the benefit was partial; in another 7 per cent. the pain was not relieved. These conclusions were derived from 37 cases only, but in the balance of them (23 per cent.) there had been either no pain or no operation, or the pain was relieved in another way, as by the the terchloride of antimony, of which a saturated solution was successfully applied to remove the deposit. The beneficial effects of an operation, though only resorted to for its palliative effects, are here plainly shown.

(*j*) Average duration of the disease. Of 21 cases which were alive at last accounts, the average duration was 67 months, the least being 5 months, and the greatest 207 months.

Of 19 fatal cases, the average duration of 16 was 34 months, the range being from 4 to 154 months. Mr. Paget states that "the average duration among 14 patients, in whom it commenced below 45 years of age, was 39 months; that among 17, in whom it commenced later, the duration was 45.5 months." Of 6 fatal cases in my tables, the average duration of life, when the disease occurred before 45, was only 18 months; after 45 it was 47 months.

According to Mr. Sibley,[18] who derived his information from the Middlesex Hospital Reports, epithelial cancer destroys life, on an average, in 53 months. He based his figures largely on epithelioma of the lip.

2. *Scirrhous Carcinoma.*—(*a*) Age. Of 180 cases the disease was found to commence most frequently in those forms that were directly accessible to the knife, between the ages of 42 and 46. The earliest appearance of scirrhus occurred at the age of 28; the latest at 76. If it be realized that of these 180, 130 were located in the breast, it will be seen that the statistics are mainly those of mammary scirrhus.

On the other hand, when scirrhus occurred in internal organs not directly accessible to the knife, the largest number originated between the ages of 50 and 54, the range extending from 23 years to 74, with 50 as the average age of commencement. Mr. Paget gives the half decade between 45 and 50 as the period at which scirrhous carcinoma (breast) most frequently occurrs. Whether scirrhus may occur in infancy must be still a matter of uncertainty, although the late Dr. Gross [19] has instanced a case in which a mulatto child, three months old, had a small scirrhous deposit in its liver; it may be remembered that at the date when this statement was made no rigid distinction between carcinoma and some other malignant growths had been generally recognized.

(*b*) Sex. Of the external cases of scirrhus, 95 per cent. occurred in females, 5 per cent. in males; this disproportion between females and males being due chiefly to the fact that scirrhus of the female breast was, as has already been shown, the most frequent form of the disease; on the other hand the reverse was found to be true with those growths that are termed internal, 72 per cent. being in males and 28 per cent. in females. Of the breast cases 98 per cent. occurred in females, 2 per cent. in males. Mr. Paget says: "Probably in every 100 cases of scirrhus of the breast, 98 occur in women,"—an extraordinary agreement in percentages.

(*c*) Locality. The order of frequency was found to be as follows, including all forms of scirrhus, whether external or internal: Breast, including nipple, 130; stomach, 14; uterus, 8; liver and stomach, 4; neck, 4; rectum, 4; bladder, 2; pancreas, 2; axillary glands, 1; back, 1; colon, 1; duodenum, 1; foot, 1; gall-bladder, 1; ileocæcal valve, 1; nose, 1; parotid region, 1; superior maxilla, 1; cheek, 1; œsophagus, 1; total, 180.

(*d*) Cause. According to my tables, in 55 cases distinct inquiry was made as to the supposed cause. In 19, or

35 per cent., no cause had been recognized, so that if the disease were traumatic in its origin the patient was certainly not aware of it; on the other hand, in 24, or 44 per cent., the following traumatisms were given as causes: a blow, an abscess, ulceration of the nipple, laceration from decayed tooth, friction of breasts against a washboard, a scratch, tight corsets, a strain from lifting, falls in which the breasts were injured. In the remaining 12, or 21 per cent., no definite information was obtained. In 46 cases of scirrhus of the breast the influence of traumatism as an etiological factor is more apparent, for in 23 cases (50 per cent.) an injury or surgical affection was alleged as the cause. Mr. Paget gives only 17.5 per cent., under similar circumstances. (See Carcinoma of the Breast.) In the 14 cases of internal scirrhus no causes were alleged except once, in which case, one of cancer of the stomach and liver, the disease was attributed to a strain.

(*e*) Family history. Of 52 cases of scirrhus accessible to the knife, in 33, or 63 per cent., there was no family history of carcinoma; in 8, or 15 per cent., there was said to be cancer in the family; but whether the growths were malignant merely or true carcinoma could not be determined. This percentage must therefore be reckoned as a high one. In 2 cases, or 4 per cent., there was a family history both of carcinoma and phthisis; in 3, or 6 per cent., there was a family history of phthisis alone; in 1, or 2 per cent., there was a family history of phthisis and syphilis; in 2, or 4 per cent., a relative died of uterine tumor; in 1, or 2 per cent., there was quite probably a history of carcinoma in the family. In 2, or 4 per cent., no history could be obtained. Including, therefore, all possible cases, embracing those in which no statement was made on this point, in 27 per cent. a family history of cancer might be traced, though in 71 per cent. such a family history was denied. In 12 per cent. there was a family history of phthisis, a percentage which would tend to demonstrate that there is no interrelation between it and carcinoma, for this ratio would demonstrate conclusively that phthisis is not quite so common in cancerous families as in the generality of mankind. But, on the other hand, if we add all the forms of scirrhus, including external and internal forms together, in which this point was made a matter of specific inquiry, it appears that of 68 cases only 13, or 19 per cent., showed a family history that could with any proper degree of justice be called carcinomatous.

Mr. Paget says: "In 88 patients, including 4 cases from other organs than the breast, in 16, or 18.18 per cent., there was family history of carcinoma, but the proportion is larger if calculated from a large number of private patients."

(*f*) Pain. This point was studied in 41 cases accessible to the knife, and it was found that in 29, or 71 per cent., there was a clear history of pain (severe in character); in 7, or 17 per cent., there was moderate pain; in 3, or 7 per cent., there was no pain; in 2, or 5 per cent., the matter was unknown. Of 13 internal carcinomas, in 9, or 70 per cent., there was decided pain in the affected locality; in 2, or 15 per cent., it was slight, while in an equal number there was no pain.

(*g*) Implication of lymphatic glands. Of 59 cases of internal scirrhus, in 37, or 63 per cent., the lymphatic glands were found to be enlarged; in 22, or 37 per cent., the matter was not noted or none were found. This matter is, however, of comparatively little importance, because the lymphatics are sure to be involved if the disease reaches a certain maximum of development; and the failure to find this complication indicates either that the disease is comparatively recent or that the glands have escaped notice, a circumstance that frequently happens when the carcinoma attacks internal organs. Thus of 17 cases of internal scirrhus in only 7, or 41 per cent., was it positively stated at the autopsy that the glands were involved; in 10, or 59 per cent., they were not noted, and yet a more careful inspection would pretty certainly have detected them in many of the cases.

(*h*) Previous health. Of 57 cases in which the disease was external, in 42, or 74 per cent., the general health had been good up to the inception of the attack; in 3, or 5 per cent., there had been syphilis; in 6, or 11 per cent., the previous health had not been good, but the troubles had no apparent relation with the fatal disease so far as its cause was concerned, the preceding disorders coming under the head of nephritis, ascites, general debility, *i.e.*, where they were named.

Of 20 internal cases of carcinoma, in 18, or 90 per cent., the general health had been good; in the 2 (10 per cent.) in which the previous health had been poor, dysmenorrhœa, constipation, and dyspepsia were the disorders found.

Of 49 cases involving the breast, in 40, or 82 per cent., the health had been good in all but 2. Hence it may very properly be inferred that scirrhous carcinoma is a disease that occurs by preference in persons whose previous health has been good, and the claim of some writers that cancer is a disease of the "robust" has some apparent foundation. At the same time carcinoma must be recognized distinctly as a disease of the waning years of life, when degenerative processes are at work.

(*i*) Relief of pain by operation. This is an important consideration, and fortunately for surgery it is shown, of 37 out of 58 cases (64 per cent.), that there was decided relief from this symptom after operation. Of 50 breast cases the pain was relieved in 35, or 70 per cent. Of course these statistics have comparatively little value in showing the advantages of an operation in this respect; for if, as occurred in some instances, the growth was not wholly removed, the pain very naturally continued, while, on the other hand, a complete removal of the source of trouble was tantamount to a relief from the pain.

There is an important consideration which should be borne in mind in discussing the value of an operation: I refer to the fact that even if surgeons cannot claim that they have retarded the development of the disease, they have a right to maintain that the operation will in the first place be painless, thanks to the influence of anæsthetics; secondly, that the patients will be rid of the manifestations of a loathsome disease, offensive to themselves and others; and, finally, that they will have immunity for months, possibly years, during which time they may travel, visit their friends, and have ample opportunity to prepare for an issue that will in the vast majority of cases be a fatal one, notwithstanding all that modern surgery can accomplish. The danger of the operation proving fatal from some cause connected with it, may be regarded as comparatively slight; it amounts to 5 per cent., and the causes are hæmorrhage and shock.

(*j*) Does an operation prolong life? This question is best answered with reference to some special form of the disease in a particular organ. My statistics in 19 cases (46 per cent.) would indicate that the growth was more rapid after removal; in only 3, or 7 per cent., was it stated that the disease which recurred was less rapid in its development.

Mr. Paget thinks that the recurrent local disease appears generally to be less intense than the primary,[20] and this view is sustained by considering

(*k*) The average duration of the disease as judged from fatal and non-fatal cases, of my tables. Of 49 cases, including 28 in which all record was lost after an immunity of many months, and 21 fatal cases, in which death was due to the disease itself and not to complications, in all of which 49 cases there had been operative interference, the average duration of life was 46.8 months, while in 4 cases, in which no operation was performed, the average duration was 35.7 months. It is evident, therefore, that these figures indicate, if they represent the ordinary history of such cases, that operations lengthen life to the extent of more than eleven months, on an average. This estimate, I believe, is a low one. Sibley puts the average duration of scirrhus at 32.2 months.

A few remarkable cases, taken from my experience, illustrate the character of cases in which the most favorable results are reported.

A. M——, a woman, sixty years of age, fell, striking her breast, in 1827; a tumor developed which was removed in 1877; it then proved to be a carcinoma; four years subsequently it had not returned.

In another case a lady, Mrs. L——, first noticed a tumor

of the right breast in September, 1857; subsequently the axillary glands became involved; operations were performed in 1875, 1877, and 1878, but the disease was never eradicated. She had lived, up to the last report, 256 months, or more than twenty-one years since the breast first became affected.

It is but proper to state that these two cases are excluded from the computations because it may be claimed that the growths were at first benign, since they gave none of the ordinary characteristics of malignancy during the early years of their presence. (For other remarkable cases, see Carcinoma of the Breast.)

3. *Medullary or Encephaloid Carcinoma.*—(*a*) Age. Medullary carcinoma may occur at any age, perhaps, but is more likely to select some period between twenty and eighty, and no one decade appears to have any precedence over another.

(*b*) Sex. The sexes are equally prone to it.

(*c*) Locality. It is a disease that is chiefly confined to the internal organs; thus of 10 cases in my records, in 4, or 40 per cent., the liver was selected; in 1, or 10 per cent., the kidney; in 1, or 10 per cent., the vagina; in 1, or 10 per cent., the ovary; in 1, or 10 per cent., the liver, kidney, spleen, lung, and pancreas; in 2, or 20 per cent., the left breast.

(*d*) Etiology. This point is less clear than in epithelioma or scirrhus: thus of 11 cases in only 3, or 27 per cent., was there any assigned cause; in these three cases the causes were: in one of renal cancer, a renal calculus; in one of vaginal cancer, an abortion, and finally, in one of hepatic cancer, an injury over the region of the liver.

(*e*) Family history. Of 7 cases in which this topic was made a matter of inquiry, in only 1, or 15 per cent., was there a history of constitutional disease in the family, and in this case it was phthisis, but we shall do well to remember that this taint of phthisis will be found to exist in the family history of one in every seven persons of the community at large.

(*f*) Pain is usually a characteristic phenomenon; it was present in nine out of eleven cases, and was usually described as severe; less often it was slight.

(*g*) Implication of lymphatic glands. This point is not so well characterized in medullary cancer, because in the first place the chief nidus of the disease is in the tumor itself, rather than in the lymphatics, so that the latter enjoy comparative immunity, or at any rate attract little attention. At any rate it may be put down that the glands are not appreciably involved in 20 per cent. of the cases.

(*h*) Previous health. So far as we are able to learn, the previous health of patients with this form of cancer had been remarkably good. My records show this positively in 55 per cent.

(*i*) Duration of life. As we should expect from a growth that is so exuberant as medullary carcinoma, the patients have a comparatively short lease of life. This disease is the most rapidly fatal of all. Thus six fatal cases in my tables lived an aggregate of thirty months (an average of five). And yet this is not uniformly true. Thus in two patients who were alive on January 1, 1879, one had lived sixty-one months and the other fifty-six months.

General Considerations.—It may be said in the first place that there is positively no danger to the skilled microscopist in distinguishing between carcinoma and other growths, whether malignant or benign. And there is usually no difficulty in distinguishing the special variety. A somewhat lengthy examination is sometimes required, but of the ultimate result there should be no doubt. In fact, certainty as to the structure of a growth can only be reached by the microscope (see the preceding article, on Carcinoma: Pathological Anatomy). Nor does the type change during its growth, or in its recurrence, to any marked extent. It must be admitted that a benign tumor may eventually become cancerous, for our clinical records appear to have shown such instances, but the reverse is never the case. Nor does a carcinoma ever become a sarcoma, or the reverse. The most that can be said on this point is that an epithelioma may develop in its advanced stages from the superficial form to the deep form, and that a scirrhus of the breast may recur in the internal parts, the liver more especially, as a medullary carcinoma, and that colloid changes may occur in either of these; but even such an occurrence is not common. There is, however, no very sharp line of distinction in all cases between these tumors just mentioned, and we may sometimes find their separate elements combined in a single tumor. A further point remains, which is now attracting general interest in some quarters; I refer to the general relation of phthisis to carcinoma. My tables show the following: Of 68 cases, in only 7, or 10 per cent., was there any phthisis or cancer in the family, and in only 6 was there any complication of the respiratory organs that hastened death; in 3 of these this relation was stated to have existed, and yet in 1 of them the account was dubious; but adding these 3 to the 7, we have 10 out of 68, a percentage of only 15, in which by any possibility it could be shown that phthisis was an etiological factor in the production of the disease; but these figures bring us again back to the fact that the general community is affected with phthisis in just about this same ratio. *Thomas E. Satterthwaite.*

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CARDAMOM (*Cardamomum*, U. S. Ph., Br. Ph.; *Fructus Cardamomi*, Ph. G.; *Cardamome du Malabar*, Codex Med.; Cardamons). The fruit of *Elettaria Cardamomum* Maton (*Alpinia Cardamomum* Roxburgh); Order, *Scitamineæ, Zingibereæ*. This is a tall, flag-like, perennial herb, arising from a thick fleshy or woody rhizome. The leafy stems are from two to four metres (six to twelve feet) high, upright and simple; the leaves large, two-ranked, with sheathing petioles and long, lanceolate, pointed blades. The flowering stems arise from the upper nodes of the root-stock, they are scaly, slender, zigzag, and straggle near the ground, bearing small alternate clusters of bracted flowers. The flowers themselves are above an inch in length, and have the remarkable structure of the order in general, viz., a superior "calyx" tube, with three short lobes; a "corolla," also tubular and three-lobed, and an andrœcium of six parts in two series, of which one in the outer series is developed into a large petaloid, spatulate, rose-tinted lip, and one in the inner, into the only normal stamen of the flower; the remaining four stamens being small, inconspicuous scales or points. Ovary three-celled, rather many-seeded; style, long and slender. The cardamom plant seems to be a very variable species, both as regards the size and shape of the fruit, and the proportions of the flower. It is a native of Southern India, where also it has been long in cultivation. It has been introduced into other tropical countries. The cardamoms of commerce are mostly the product of cultivated plants, which are planted in the moist shade; either in clearings of the natural forests, or in plantations of betel palms; they are gathered before they are quite ripe and dried sometimes with, and sometimes without, artificial heat. They are ovoid or oblong, pointed, rounded-trianglar, three-valved, and three-celled capsules. The husk, when dried, is of a pale yellowish-gray or brown, flexible, and tough. The seeds, five or six in each cell, are irregularly compressed, brown, and spicy. Size: The fruits of the best varieties are usually short, about once and a half or twice as long as broad (one to one and a half centimetre, 0.01 to 0.015 metre = $\frac{4}{10}$ to $\frac{6}{10}$ inch), very plump and full. They are commercially called "shorts." Others, longer and more angular, are denominated "short-longs" and "longs."

The longest, from one to two inches in length, are the "*Cardamome de Ceylon*," or *Grand Cardamome* of the Codex Med.

Cardamoms are also distinguished according to the countries or ports from which they are exported, as Malabar, Aleppo, Madras, etc. The former are the most esteemed.

Composition.—The capsules have no active properties. The seeds contain about five per cent. of a pale yellow aromatic oil, which represents them in odor and taste. The ash of Cardamom is rich in manganese. It is a typical aromatic, and is useful in all the conditions which call for articles of that class. As an agreeable flavor and appetizer, as a stimulant to digestion, a carminative in flatulence, and in simple colic, it is sometimes, but not often, given alone. In combinations, as a pleasant and useful adjuvant and corrective, it is in more frequent use, acting favorably with cathartics, bitter tonics, stimulants, etc. But the principal use of Cardamom is as a condiment or household flavor, for which purpose, especially on the continent of Europe and in the East, it is extensively employed. It is also used in flavoring liqueurs, and in curry-powder, etc. It is less irritating than the spices proper, and more so than Anise and the milder carminatives. The dose of Cardamom as an aromatic by itself would be from one-half to one gram (0.5 to 1 Gm. = gr. viij. ad xv.). There is a tincture (*Tinctura Cardamomi*, U. S. Ph., $\frac{15}{100}$) which represents it completely. The compound tincture (*Tinctura Cardamomi Composita*, U. S. Ph.) contains two per cent. each of Cardamom and Cinnamon, one of Caraway, six of Glycerine, and one-half per cent. of Cochineal in diluted alcohol. Dose, five to ten grams (5 to 10 Gm. = ʒ j. ad iij.). The aromatic powder (*Pulvis Aromaticus*, U. S. Ph.) contains thirty-five parts each of Cinnamon and Ginger, fifteen each of Cardamom and Nutmeg. Dose, one to two grams (1 or 2 Gm. = gr. xv. ad xxx.). The Aromatic Fluid Extract (*Extractum Aromaticum Fluidum*, U. S. Ph.) represents the above in fluid form; dose the same. There is a little Cardamom in the Pills of Aloes and Myrrh, and in the Compound Tincture of Gentian, U. S. Ph.

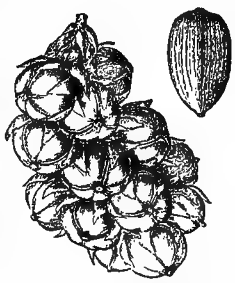

Fig. 566. Cardamom. Cluster of fruits and single fruit, slightly reduced (Baillon), of the "cluster cardamom."

Allied Plants. — Besides the varieties of Cardamoms above mentioned, several very similar products are yielded by neighboring genera, one of which, the cluster cardamom (*Amome en grappe*, Codex Med.), not common in this country, but abundant in Indian commerce, is figured. It is from *Amomum Cardamomum* L., of Siam. Several other species of Amomum yield varieties of Indian Cardamoms. Grains of Paradise is the fanciful name given to the peppery seeds of *Amomum Melegueta* Roscoe, of Africa, which are imported into Europe and America in moderate quantities. They contain an aromatic oil, and have formerly been a favorite condiment, but are obsolete now, excepting, perhaps, in combination with other spices in cordials. They find some employment in veterinary practice. For further botanical comparison, see Ginger.

Allied Drugs.—Calamus, Cinnamon, Anise, Ginger, etc.

W. P. Bolles.

CARDIAC DEPRESSANTS. The drugs ordinarily employed to depress the activity of the circulation will only be alluded to here. These are tartarized antimony, aconite, and veratria.

These three substances agree in the particular that each possesses marked cardiac sedative properties, while in many other respects their actions are entirely different. The very remarkable action of veratria on muscle contraction, compared with that of tartarized antimony, is a good illustration of the truth of the latter statement.

Tartar emetic lessens both the force and frequency of the cardiac contractions. It is a direct poison to the cardiac muscle. It brings the heart to a standstill in diastole when given in poisonous doses.

The action of aconite on the heart is very similar to that of tartar emetic. In moderate doses it is able to reduce the number and force of the heart's beats. A reduction of thirty or even forty beats in the minute is often seen from large medicinal doses.

When this drug is given in large and dangerous doses, the slowing gives place to quickening and irregularity. A very quick pulse is a sign of more pronounced cardiac weakness than even a weak pulse. The weaker the heart becomes the faster it beats, until it finally ceases.

Aconite affects the heart after section of the vagi, and after its removal from the body, so that its influence is directly on the muscular structure or the ganglia contained therein.

It is probable that aconite acts as a cardiac depressant by a direct action on both these mechanisms. Aconite also lowers the blood-pressure.

Veratria, an alkaloid obtained from the sabadilla veratria, veratrum viride, and the veratrum album have similar actions on the heart. They are all powerful cardiac depressants.

Veratria seems to have a more depressing effect on the heart than either tartar emetic or aconite. It differs from aconite, but resembles tartar emetic in its liability to produce vomiting. If the latter is induced the slowed pulse becomes quick. The same quickening of the pulse occurs if the patient makes any sudden movement. The action of the veratrum group on the heart is brought about by a direct influence on the muscular structure. It does not exert any influence on the vagus. It prolongs the ventricular dilatation.

Much has been written on the powers said to be possessed by cardiac sedatives in reducing and even preventing inflammatory fevers, etc. For many decades tartar emetic has been in use, by English physicians particularly, with the above object. In acute rheumatism, but especially in pneumonia, it has been extensively employed. In the same disease aconite and veratrum viride have also been much employed on this side of the Atlantic. In many quarters it is the almost invariable custom to treat a pneumonia, no matter in what kind of a subject it occurs, whether in a robust or in a delicate subject, with one of these cardiac sedatives. Some American physicians go so far as to say that they are able to abort a pneumonia by the full and timely administration of either aconite or veratrum viride, but the great number of reports published as to the efficacy of this drug in pneumonia are worthless, for they are lacking in that scientific precision the presence of which alone enables the reader to judge of their value. It is extraordinary how few of the writers seem even to think of the self-limited course of a disease like pneumonia. Professor Stillé ("National Dispensatory," p. 1599), on this subject, writes: "The only conclusion to be drawn from a critical study of the mass of conflicting evidence respecting its use in the disease referred to is, that the patients would have been better not only without its use, but also without that of the medicines associated with it." In administering any cardiac depressant in the beginning stages of pneumonia, we should always remember that the great majority of deaths in this disease take place from heart-failure, and that we may directly contribute to this end by the injudicious employment of our agents.

Again, another important point to be taken into consideration is that these agents seriously interfere with digestion. This is especially true of the veratrum group and of tartar emetic. The use of any of this group in pneumonia should be confined solely to the first day or two of the disease, and then only given if the subject is robust. When continued longer than the time specified, their use can only be productive of harm, and very frequently of great harm.

In any stage of the disease occurring in weakly persons they should never be administered.

Since the introduction of salicylic acid in the treatment

of acute rheumatism, there is no occasion for the administration of cardiac depressants in this disease. The only legitimate field for the employment of these agents as cardiac depressants is in the acute catarrh of the respiratory passages in adults.

Acute bronchitis occurring in an otherwise healthy adult yields more quickly to one of these agents than to any other class of remedies. They should only be given during the "dry stage" of the catarrh; after this is passed other remedies are indicated. Of the three drugs under consideration tartar emetic is undoubtedly the most powerful in bringing about resolution of the inflammatory process in this disease.

In tonsillitis and acute pharyngeal catarrh any one of the three may be employed with confidence, but aconite, especially in tonsillitis, is the most trustworthy.

In treating this disease with aconite it is essential to success that it should be given early. If administered early enough, the beneficial effects soon become strikingly manifest. Two or three drops of the tincture every half hour for three hours, and afterward every hour, will nearly always be effective.

The presence of a high temperature in acute tonsillitis is a marked indication for the use of aconite.

James Stewart.

CARLSBAD is one of the most important thermal stations of Europe. The place is said to have derived its name from the Emperor Charles IV., to whom the legend ascribes the discovery of the medicinal properties of the waters. The town is situated in Bohemia, on the Tepel River, some seventy miles distant from Prague, and lies at an altitude of about twelve hundred feet. The valley in which it lies is shielded from the south and east winds by the mountains, but is exposed to the winds from the north and west, and the climate is consequently somewhat trying and subject to sudden changes in temperature. The native population is about ten thousand, and the number of visitors in the season, which extends from the middle of June to the middle of August, is from fifteen to twenty thousand. There are two large hospitals, one civil and one military, besides a number of hotels and lodging-houses. The springs issue from apertures in the rocky shell upon which most of the town is built, and are twelve or more in number. The temperature of the different springs varies from 122° to 163° F. The following are the names of the six principal springs, with the temperature of their waters: Sprudel, 163°; Neubrunnen, 138°; Mühlbrunnen, 127°; Schlossbrunnen, 122°; Theresienbrunnen, 122°; Marktbrunnen, 118°. The waters of Carlsbad are classed among the thermal alkaline sulphated waters. Although they were originally employed exclusively for bathing, they are now chiefly taken internally. There are, nevertheless, numerous facilities for water-, vapor-, and mud-baths, and these are used to some extent in conjunction with the internal administration of the waters. The ordinary dose is five glasses, of about half a pint each, taken during the space of an hour to an hour and a half. The following is the composition of the Sprudel water, according to the analysis of Ragsky: Each litre (1.76 pint) contains: Sulphate of sodium, 2.372 Gm. (35.58 gr.); sulphate of calcium, 0.163 Gm. (2.44 gr.); chloride of sodium, 1.030 Gm. (15.45 gr.); carbonate of sodium, 1.361 Gm. (20.415 gr.); carbonate of calcium, 0.297 Gm. (4.455 gr.); carbonate of magnesium, 0.124 Gm. (1.86 gr.); carbonate of strontium, 0.0008 Gm. (0.012 gr.); protoxide of iron, 0.002 Gm. (0.03 gr.); protoxide of manganese, 0.0006 Gm. (0.009 gr.); fluoride of calcium, 0.003 Gm. (0.045 gr.); phosphate of calcium, 0.0002 Gm. (0.003 gr.); silica, 0.0072 Gm. (0.108 gr.). Some of the other springs contain slightly larger amounts of strontium and manganese, and also traces of the iodide and bromide of sodium. The water is heavily charged with carbonic acid, one litre containing 210.59 c.cm. The Carlsbad waters are highly prized in the treatment of gastric, hepatic, and intestinal disorders; in diabetes, gravel, gout, rheumatism, chronic affections of the conjunctiva and deeper structures of the eye, and chronic aural catarrh. They are laxative, when taken in quantity, and are useful in chronic constipation, especially when associated with hypochondriasis, in congestion of the liver and spleen, and in general in all the manifestations of abdominal plethora. They are used in the treatment of dyspepsia, and even of simple gastric ulcer. Patients suffering from chronic diarrhœa, dependent upon intestinal catarrh, from gall-stones, or from icterus following catarrh of the bile-ducts or of the duodenum are often greatly benefited by a course of the waters at this place. Many functional disorders resulting from chronic congestion and enlargement of the uterus are cured at Carlsbad. In the treatment of many diseases of the eye and ear much use is made of vapor-baths.

Thomas L. Stedman.

CARROT (*Carotte*, Codex Med.). The root of *Daucus Carota* L; Order, *Umbelliferæ*. This plant is a native of Europe, but freely naturalized in the United States. (Wild Carrot.) The cultivated form is the common table carrot, grown everywhere. The fruits of carrot have been used as aromatic diuretics; the roots made into pulp as poultices; but neither have any claim to medical notice. The coloring-matter of carrot root is called *Carotin*.

ALLIED DRUGS, ETC.—See ANISE. *W. P. B.*

CARTILAGE. Under this name is classified one of the important members of the group of connective-tissues, which is characterized not so much by the structure and arrangement of its cells, as by the peculiar nature of its basement-substance. Cartilage occurs in three tolerably distinct forms, whose differences depend largely upon peculiarities in the structure of the basement-substance. These forms are called *hyalin cartilage*, *fibro-cartilage*, and *fibro-elastic cartilage*.

The most abundant and typical of these is *hyalin cartilage*. This, in the adult, is found covering the articular surfaces of bone, forming parts of the ribs and of the walls of the trachea and bronchi, and in less considerable masses in other parts of the body. Hyalin cartilage is translucent and of a bluish white color, is firm in consistency, and elastic. Like other members of the connective-tissue group it consists of cells and an intercellular or basement-substance. The basement-substance is for the most part quite homogeneous in the fresh condition, but it is occasionally very finely granular. By suitable treatment with chemical agents, it may be seen to contain, and almost to consist of, exceedingly minute and delicate fibrils, which under normal conditions are merged into a homogeneous mass. The basement-substance is said by some observers to be penetrated by minute branching canals which communicate with one another and with the spaces in which the cells lie, but this has not, in the writer's opinion, been fully demonstrated in the higher animals. Mucin and gelatin, and a rather indefinite substance called chondrin, have been obtained from the basement-substance, but our knowledge of the chemical nature of these substances, and particularly of their existence in the cartilage in the natural condition, before being exposed to chemical manipulation, is still too indefinite to enable us to speak very positively of its chemical constitution.

The cells of hyalin cartilage differ considerably in shape and arrangement in different cartilages and in different parts of the same cartilage, depending, apparently, to a considerable degree, upon the conditions of pressure to which they are subject, as well as upon the intimate constitution of the basement-substance and the influences under which its development transpires. The cells, except near free surfaces, or where cartilage and fibrous tissue join, are in general spheroidal, ovoidal, ellipsoidal, or somewhat flattened at the sides, and lie unevenly distributed in the basement-substance. The cell body is finely granular, or in some animals contains delicate fibrils, and may enclose droplets of fat, and pigment particles, or may also contain glycogen. The nuclei—of which there may be one or more—are usually spheroidal, sharply outlined, and contain more or less well-marked networks

of coarser and finer fibrils and nuclei, in which, during life, in some animals, slow oscillatory movements may be seen. The cartilage cells may lie singly in the basement-substance, but they are more frequently arranged in groups of two, or four, or more, and the cells forming these groups are apt to be flattened on the sides which abut on one another. Under normal conditions the cartilage cells completely fill the spaces in the basement-substance in which they lie. But on exposure to the air, to water, to electric shocks of moderate intensity, to a variety of chemical agents, and under certain pathological conditions, they separate from the walls of the spaces and shrink into irregular-shaped, coarsely granular masses (Fig. 569), in which the nucleus may be partially or entirely concealed. This shrinkage may be only partial, some portion or points remaining adherent to the sides of the cavities, so that the shrunken cells may appear irregularly stellate or have festooned edges. In this shrunken condition we usually see the cells of cartilages which have been preserved in alcoholic fluids. In some parts of the articular, and also in the costal cartilages, the cells lie in large groups, or in longer or shorter rows. At the free surfaces of cartilage, or where it comes in contact with the perichondrium, the cartilage cells are usually flattened, and just beneath the perichondrium may merge imper-

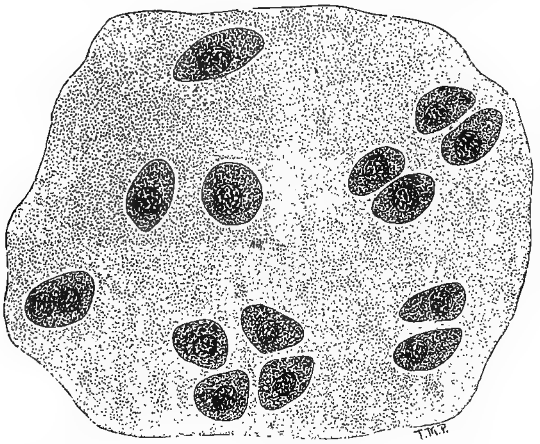

Fig. 567.—Hyalin Cartilage from the Head of the Femur of Frog. (× 700 and reduced.)

ceptibly into the ordinary flattened cells of the connective-tissue. The basement-substance immediately about the cartilage cells may be seen, under favorable conditions, to be more transparent than the rest, the more transparent zone being sometimes very thin and sometimes of considerable thickness. This portion of the basement-substance is called the capsule, and is believed to be that part which was last formed around the cartilage cell. Somewhat similar appearances may be seen not only around single cells, but around all groups which have apparently been derived from some single cell originally occupying their position in the basement-substance.

The basement-substance of hyalin cartilage may, under a variety of conditions, become infiltrated with salts of lime, and thus assume to the naked eye a white opaque appearance, and under the microscope appear crowded with larger and smaller distinct granules. Under pathological conditions the basement-substance may become fibrillar as well as calcified. Cartilage is surrounded, except over the articular surfaces, by a vascular layer of fibrillar connective-tissue called the *perichondrium*. The perichondrium contains a varying amount of elastic fibres. The fibrillated fibres of the perichondrium pass on into the hyalin basement-substance of the cartilage, into which they become gradually merged. Although vessels from the perichondrium sometimes penetrate for a short distance into the cartilage tissue, the latter is, in general, non-vascular.

DEVELOPMENT OF HYALIN CARTILAGE.—At a very early period hyalin cartilage consists of a congeries of rounded cells closely packed together, with a small amount of intercellular substance around each cell. The intercellular substance gradually increases in amount, and the cells divide; new capsules, *i.e.*, new portions of intercellular substance, are formed around the new cells, while the old capsules are expanded and appear to coalesce with those of adjacent cell-groups to form the homogeneous basement-substance. In this way the cells become gradually separated from one another, but may still retain a grouping, which indicates their primitive relations to each other.

Schleicher has shown that in the division of cartilage-cells, while the changes in the nucleus are in general those common to the indirect mode of cell division (see Cell), the separation of the body occurs, not by a gradually deepening constriction as in cells which are surrounded by a fluid or yielding material, but by the formation of a partition out of the intracellular filaments. This partition finally becomes continuous with the capsule around the new-formed cells, and thickens with their separation from one another. The exact way in which the capsules and intercellular substance originate, whether by a separation of a portion of the periphery of the cells, or whether it is simply formed under their influence, or entirely apart from them, is not certain.

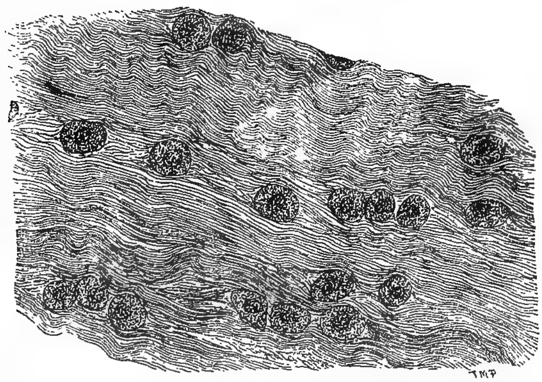

Fig. 568.—Fibro-cartilage from the Head of the Femur of Rabbit. (× 700 and reduced.)

FIBRO-CARTILAGE.—This variety of cartilage is found in the interarticular cartilages of some of the joints, such as the knee and jaw, between the vertebræ, at the symphysis pubis, around the tendons of certain muscles, and at points where tendons are inserted into hyalin cartilage, as at the junction of the ligamentum teres with the head of the femur. The cells are similar to those of hyalin cartilage, but the basement-substance is fibrillated, the fibrillæ being arranged in dense bundles or interlacing in all directions. The cells are frequently arranged in rows between the bundles of intercellular fibres (see Fig. 568), and are less uniformly distributed than are the cells of hyalin cartilage. This form of cartilage frequently merges, in structure, on the one hand into fibrillar connective-tissue, and on the other into hyalin cartilage.

FIBRO-ELASTIC CARTILAGE (yellow elastic or spongy cartilage).—This form of cartilage is not abundant in the body, being found in small masses in the external ear, Eustachian tube, epiglottis, and in some parts of the larynx. It is tough, opaque, and yellowish in appearance. The cells, which are irregularly distributed through the basement-substance, are similar in appearance to those of hyalin cartilage. Around each cell is a narrow, strongly refractile, homogeneous zone of basement-substance—the capsule. Outside of the capsule the basement-substance is more or less densely filled with coarser and finer anastomosing and interlacing elastic fibres (Fig. 569). In addition to the elastic fibres the basement-substance contains numerous large and small granules, consisting of

a material similar in chemical and optical properties to that composing the elastic fibres—the so-called elastic granules. These elastic granules are unevenly distributed

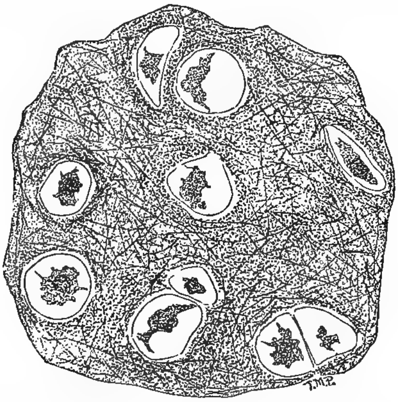

FIG. 569.—Fibro-elastic Cartilage, from Epiglottis of Man. × 700 and reduced. Specimen preserved in alcohol and the cartilage cells are shrunken.

through the basement substance. Fibro-elastic cartilage is developed from a hyalin form of cartilage by the formation, in the basement-substance, of the characteristic elastic fibres and granules.

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T. Mitchell Prudden.

CASCARILLA, U. S. Ph. (*Cascarillæ Cortex*, Br. Ph.; *Cortex Cascarillæ*, Ph. G.; *Cascarille officinale*, Codex Med.; Eleutheria Bark). *Croton Eleuteria* Bennett, which yields the above-named bark, is a small tree with slender, wand-like branches, and ovate, tapering-pointed leaves; these latter are perfectly covered below with peltate and stellate scales. Flowers small, in racemes, monœcious, sweet-scented. Bark fragrant. It is an inhabitant of Cuba and the Bahama Islands.

Cascarilla was imported into Europe about the middle of the seventeenth century, when it was considered a variety of, and often confounded with, cinchona. It has undoubtedly formerly been the produce of several species of *Croton*, but at present comes exclusively from the one above named. It is "in quills or curved pieces, about one-twelfth of an inch (two millimetres) thick, having a grayish, somewhat fissured, easily detached, corky layer, the remaining tissue being dull-brown, and the inner surface smooth. It breaks with a short fracture, having a resinous and radially striate appearance; when burned it emits a strong, aromatic odor; its taste is warm and very bitter."

The active principles of this bark are *cascarillin*, a white crystalline. bitter substance, scarcely soluble in water, to which it owes its tonic properties, and an *essential oil*, which latter it contains to the extent of something more than one per cent. This is a compound oil, consisting of a terpene and an oxygenated portion. It also contains some *resin*.

ACTION.—The composition just given indicates the use and value of cascarilla. It is a bright, rather pleasant, aromatic, bitter tonic, with no special qualities other than its taste, to distinguish it in medicinal value from other spicy bitters. It is used occasionally in pastilles, and said to be put into tobacco on account of its fragrance when burning. There is no officinal preparation. Alcohol extracts its virtues to the best advantage. Dose, as a tonic, one or two grams.

ALLIED PLANTS.—The section *Eleuteria*, of the enormous genus *Croton*, contains twenty-five or more plants, a number of which have barks possessing properties similar to those of the officinal cascarilla. See CROTON-OIL, also CASTOR-OIL.

ALLIED DRUGS.—All the aromatic bitters. For a notice of the order, see MAGNOLIA. *W. P. Bolles.*

CASHEW NUTS (*Noix d'Acajou*). The fruits proper of *Anacardium occidentale* L.; Order, *Anacardiaceæ*, a handsome evergreen, West Indian and South American tree, bearing its heart- or kidney-shaped fruit partly imbedded in the top of a large, pear-shaped, sweetish-acid, edible receptacle, six or eight times as large as the fruit proper; the whole is eight or ten centimetres long. The fruit itself is kidney-shaped, about three centimetres (one and a quarter inch) long, brownish-ash colored, and smooth externally. It contains a large, bland, oily, curved, edible embryo. The pericarp, which is two or three millimetres thick (one-eighth inch), is of cavernous structure, and contains, when dry, a thick or solid, black, extractiform, resinous substance, of exceedingly irritant properties when applied to the skin. A bassorin-like gum exudes from the stem; an edible milky sap, which also is an indelible dye, flows from the trunk.

The tree is cultivated in the tropical portions of both hemispheres, for its pear-like "fruits." There are six species of *Anacardium*, all inhabitants of tropical America.

The resinous extract consists of *anacardic acid*, and a yellow or brown oily liquid, *cardol*. This is an intense and dangerous irritant, causing often severe inflammation of the skin and blisters, and even the fumes when it is burned have the same properties. It, or rather the pulp of the pericarps, was formerly used as an irritant, and are still so used to some extent in the West Indies. It has no medicinal value here, and is only to be known as a poison.

ALLIED PLANTS AND DRUGS.—The East Indian *Anacardium* is a smaller but similar product, from *Semecarpus Anacardium* Linn. *fil.*, in the same order. A milder cardol, "*Cardol pruriens*," is obtained from its fruit, and has been used also as an irritant, and as a basis of indelible ink. It is entirely out of use on account of the danger attending it. Poison Ivy, *Rhus toxicodendron* L. and Poison Sumach, *Rhus venenatum*, are in the same family, and, as well as some other species of *Rhus*, have similar inflaming action upon the skin (see IVY, POISON).

W. P. Bolles.

CASSIA, PURGING (*Cassia Fistula*, U. S. Ph.; *Cassiæ Pulpa*, Br. Ph.; *Casse officinale*, Codex Med.). The fruit of *Cassia fistula* Linn.; Order, *Leguminosæ*, *Cæsalpineæ*. It is a beautiful, medium-sized tree, with large pinnate leaves, and long drooping racemes of beautiful, showy, sweet-scented yellow flowers. The ovary is long, narrow, curved, one-celled, and many-seeded, but it becomes straight as it grows, and develops transverse woody partitions between the seeds.

This tree is a native of tropical Asia, but is extensively cultivated for its beauty, both in the Old World and in the New. The drug has been undoubtedly in use for five or six hundred years, but its name is much older, having been transferred to this substance from some variety of cinnamon to which it properly belonged.

The pods of Cassia Fistula are nearly or quite straight, from thirty to sixty centimetres long, by about two and a quarter in diameter (from twelve to twenty-four inches by one inch), cylindrical, shortly-stalked, and blunt-pointed. The surface is dark-purplish-brown, and although not very smooth it has a dull polish. The dorsal and ventral sutures are marked by broad, flat, longitudinally striated bands running the length of the pod. The position of the partitions is generally noticeable upon the surface by means of shallow annular constrictions about five or six millimetres apart (one-fifth to one-fourth inch). The pericarp (shell) is very hard and brittle when dry, requiring a hammer to break it. The cavity is divided by transverse septa into from twenty-five to one hundred chambers, each containing one brown, shining, flattened seed and further filled with pulp. This last, which is the only useful portion, when the pods are fresh, is soft and fills the entire space; as they dry it hardens into a thick black extract-like mass which eventually becomes hard

and brittle and only covers the surfaces of the chambers, leaving the seed free and loose. When very dry, the quality is considered to be impaired. This pulp is removed for use by maceration. It has a sweetish, mawkish, mulberry-like taste and smell and is slightly laxative, but, at least in the dry state in which the fruits reach us, it has very little value. *Sugar*, *gum*, and other common vegetable substances are all that have been observed in it. Cassia Fistula is retained in the Pharmacopœia as a traditional ingredient of the Confection of Senna (*Confectio Sennæ*, U. S. Ph.). In the south of Europe it is more used. Dose: of the pulp, from four to twelve grams as a laxative (4 to 12 Gm. = ʒ j. ad iij.); as a cathartic, two or three times as much.

Allied Plants.—The products of one or two related species are occasionally substituted for this Cassia, or are used on their own account, *Cassia moschata* H. B. K., of New Granada, whose pods are smaller and more curved (*Casse petite*, Codex Med.), and *Cassia grandis* with very stout, three-ridged fruits (*casse du Brésil*, Codex Med.). The pulp of both of these Cassias is more disagreeable than that of the officinal one. For further botanical relations see Senna. These Cassias belong to the section *Fistula* of the great genus *Cassia*, and are very different in habit from the little shrubs or herbs that yield our Sennas.

Allied Drugs.—Fig, Prune, and other sweet laxative fruits. *W. P. Bolles.*

CASTOR (*Castoreum*, Br. Ph., Ph. G., Codex Med.). "The dried preputial follicles and their secretion, obtained from the Beaver, *Castor Fiber* Linn., and separated from the somewhat shorter and smaller oil-sacs, which are frequently attached to them." The glands or reservoirs are usually connected in pairs by their excretory ducts, which open so near together as to be removed without dividing. They are oblong or pear-shaped, somewhat shrivelled, multilocular bags, of dark-brown color (when dry) and tenacious consistence. The castor itself is within these; it is an unctuous brown or reddish-brown substance of intense and disagreeable smell. It consists of volatile *oil*, *castorin*, a *resinoid substance*, a peculiar fat, and other proximate principles, but like musk and others of its class, the chemical composition is not especially instructive as to its qualities. There are two varieties of Castor, the Siberian, from the Siberian beaver, whose "pods" are longer (6 to 12 ctm. = 2½ to 5 in.) and larger, and whose contents are more fragrant; and the Canadian, from the American variety. The latter is naturally the most common here.

This substance has been long used as a stimulant and antispasmodic in hysterical and other nervous conditions, but is now nearly obsolete as a medicine. There is some call for it as a basis of perfumes. Dose from half a gram to two grams (0.5 to 2 Gm. = gr. viij. ad xxx.).

Allied Substances, etc.—See Musk.

W. P. Bolles.

CASTOR OIL (*Oleum Ricini*, U. S. Ph., Br. Ph., Ph. G.; *Huile de Ricin*, Codex Med., the seeds are also officinal in France, *Ricin*, Codex Med.). The Castor-oil plant, "*Palma christi*," *Ricinus communis* Linn.; Order *Euphorbiaceæ*, *Crotoneæ*, is well known everywhere. In temperate climates it is a large annual herb, dying at the end of the season, often without ripening its fruit; or, where the season is long enough, as in the Middle States, it bears abundantly the first year, and is killed by the approach of winter; but below the frost line, as in the extreme south of Europe, in Africa, and India, it becomes shrubby or arboreous, attaining, in the tropics, a height of forty feet, and living a number of years. In the United States it grows from one to four metres high (three to twelve or more feet), has a round, smooth, hollow, branching stem, bearing numerous very large (up to forty or fifty centimetres long, twelve to eighteen inches) peltate or subpeltate, five to eleven or more lobed leaves. The flowers are in spike-like panicles, which, although really terminal, become apparently lateral by the continued growth of the plant from an upper axillary bud; monœcious. The lower part of each floral axis usually bears a few clusters of short-stalked, staminate flowers; the upper part is usually a true spike and covered with sessile pistillate ones. The flowers are rather large (one or two centimetres, one-half to one-fourth inch across), with a valvate calyx of four or five lobes. The male consists of innumerable, often several hundred, minute, two-celled anthers, borne upon numerous, repeatedly branching, compound filaments; the female, of a single three-celled softly prickly ovary, with three long-forked crimson styles. Fruit, a short, blunt, bristly, tricoccous

Fig. 570.—Castor-oil Plant. (Baillon.)

capsule, containing three pendulous seeds. Castor-oil seeds vary considerably in size and markings; they are generally from one to two centimetres (about half an inch) in length by about two-thirds as broad and half as thick, ovoid, blunt, and rounded at the ends. They are convex on the outer surface. The inner surface is usually flattened on each side of the middle by the pressure of the neighboring carpels, the two facets so formed uniting in a very blunt and rounded longitudinal angle. They have a good-sized caruncle at their upper end (or a scar if this has been broken off). The surface is very smooth and shining, usually of a gray color, marked with very pretty brown or blackish marblings. In color and markings, however, they may vary considerably. The nucleus consists of a soft, oily albumen, with a good-sized, straight, broad embryo in the middle. This plant is probably indigenous to India, but has been cultivated so long and extensively that its original habitat is difficult to determine. It has been completely naturalized, and grows with all the freedom of a native in other parts of Asia, as well as many of the Mediterranean islands and coasts. It is cultivated extensively for its seeds in India, Southern Europe, and the Middle United States. It is a very variable species, and is divided into numerous varieties, mostly distinguished by the size, shape, and color of capsules or seeds.

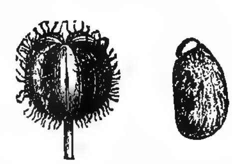

Fig. 571.—Fruit and Seed of the Above. Two-thirds natural size.

The Castor-oil plant was known to the ancient Egyptians and Greeks, and its oil used as fuel and medicine. It has even been suggested as the gourd that sheltered Jonah. After a long period of neglect, it was again brought into use, a hundred and twenty years ago, by Peter Canvane, a physician, who had practised for many years in the West Indies, and who, in a treatise upon

this oil, strongly recommended it as a gentle purgative (Pharmacographia).

The oil is separated from the seeds by the usual methods employed with fatty substances, viz., by boiling in water and skimming it off; by extracting it by means of some solvent like alcohol or ether; or by expression. The latter is the method employed in the United States. The seeds are carefully cleared from dust and fragments of the capsules, and then warmed, by which means the oil becomes more liquid. The mass is then subjected to strong pressure, and the expressed oil further purified either by standing and decantation, or by boiling with water. The yield is about forty or fifty per cent. The purer the oil is, the less active and griping it is. If expressed cold from the peeled seeds, like the best Italian oils, it is very white and odorless, and almost tasteless.

DESCRIPTION.—Good castor oil is "an almost colorless, transparent, viscid liquid, of a faint, mild odor, a bland, afterward slightly acrid, and generally offensive, taste, and a neutral reaction—sp. gr., 0.950 to 0.970. It is soluble in an equal weight of alcohol, and in all proportions in absolute alcohol, or glacial acetic acid. When cooled it becomes thicker, generally depositing white granules, and at about −18° C. (0.4° F.) it congeals to a yellowish mass" (U. S. Ph.). It is a compound of the glycerides of two fatty acids, the principal one of which is peculiar to it, and called *ricinoleic acid* ($C_{18}H_{34}O_3$), a thin, yellow, sherry-colored syrupy oil, without odor, but having a sharp and acrid taste; reaction acid. Soluble in alcohol and ether in all proportions. *Stearin* is also an ingredient of this oil, and it contains, further, a crystalline, doubtful substance named *ricinine*. The cathartic principle is probably something held in solution by the fatty substances, which, however, has not yet been separated.

Castor oil is a cathartic of very reliable character, more uniform and painless in its action, and more susceptible of gradation than almost any other. The full dose clears the bowels with great certainty, producing numerous and copious discharges of their contents, with but little irritation of their surfaces; indeed, when these are inflamed it appears to have a decidedly healing or soothing effect upon them. On these accounts, when the desire is simply to relieve the entire intestinal tract, either from the accumulated fæces or from the irritating secretions of dysentery or enteritis, castor oil is the safest and surest means at the command of the physician. For attacks, also, of acute indigestion, and for the constipation following childbirth, it has long been almost universally used. It is not a hydragogue, nor is it very well adapted for continuous use in habitual constipation, although for "weak" and sensitive conditions of the bowels, where they are easily disturbed, now a little constipated, now a little loose, with frequent slight colics and flatulent tenderness, small daily doses of this medicine may be useful. It is one of the ingredients of flexible collodion (*Collodium flexile*, U. S. Ph.), to which it gives softness and flexibility.

ADMINISTRATION.—There is scarcely a medicine in use which is generally taken by adults with so much repugnance as this. It is doubtful if children object to it any more than to medicines in general, olive oil, for instance. When it can be taken clear this is the best way, or it may be mixed with syrup or glycerine, or floated upon the surface of some aromatic water, or in the froth of soda-water containing some aromatic syrup; or a regular emulsion may be made with it, such as is made with cod-liver oil, by means of mucilage or other emulsifying agent. But the taste of the oil usually outlives that of the flavor, and they are, therefore, only partly successful. Another good way is to rinse the mouth with clear whiskey or other spirit, or lemon-juice, then immediately to swallow the oil, and follow it with another rinsing with the liquor. Finally, it is put in elastic capsules, which for small doses, in the case of patients who will learn to swallow them, completely cover the taste. All these means, however, are more adapted to grown persons than children; for these the emulsion is probably the best, or it may be covered with a little lemon-juice or glycerine. Another useful way to give castor oil, in certain cases, is by injection; in this way it acts principally locally and mechanically as a lubricant, but a certain quantity must be absorbed, as there is often more result from it than would be explained in this way. A good method is to give, for an adult, from sixty to one hundred and twenty grams (60 to 120 Gm. = ℥ ij. ad iv.) clear, to leave it from one to three quarters of an hour in the bowel, and then follow with a full enema of soap and water. Very free emptying of the lower bowel usually follows.

Castor Oil is absorbed to a slight extent by the skin, but the method has no practical value.

Dose by the mouth, as a laxative, from five to ten (5 to 10 Gm. = ʒ j. ad iij.); as a purgative, from fifteen to thirty. Children require large proportionate doses. A baby a week old can easily bear from three to five grams, and a child of five or six years ten or fifteen.

ALLIED PLANTS.—There is but one species of *Ricinus*, although the varieties are numerous and quite marked. They all yield the oil. The order *Euphorbiaceæ* is one of the largest, numbering three thousand species, by far the largest part of which are inhabitants of the tropics. Its medical properties are exceedingly various, some of its members are very poisonous. The following examples will illustrate its diversity:

1. *Euphorbia*, an enormous genus, a number of species of which have been used, none of much value. *E. corollata* Linn. and *E. Ipecacuanha* Linn. of the United States are emetics, sometimes cathartics also; *E. resinifera* and other African species furnish the resinous substance *Euphorbium*, which is an acrid cathartic.
2. *Buxus*, the common Box and allied species, contain the tonic alkaloid *buxine*.
3. *Hevea*, a number of species yield abundance of *India rubber*.
4. *Jatropa Curcas* Linn. The seeds of this species are the *Barbadoes* or *purging nuts* of South America; they resemble Croton-oil seeds but are larger; they contain an irritating purging oil like Croton Oil, but not quite so intense in their action.
5. *Croton Tiglium* Linn. furnishes *Croton Oil; Croton Eleuteria* Bennett is the source of the pleasantly aromatic *Cascarilla Bark*.
6. *Manihot utilissima* Pohl. yields *Tapioca*.
7. *Mallotus phillipinensis* J. Müll, *Kamala*.
8. *Ricinus communis* Linn., *Castor Oil*.
9. *Stillingia sylvatica* J. Mull, a purgative emetic and reputed cholagogue and alterative.

ALLIED DRUGS.—Sweet oil. For a comparison of cathartics, see RHUBARB. *W. P. Bolles.*

CATALEPSY. The cataleptic state, or one analogous to it, has been observed in a number of living beings. The phenomenon exhibited in the state of certain plants, some of the organs of which may keep a forced position given to them, is notable in the *Dracocephale Virginiana*, whose flowers, on being displaced horizontally to right or to left, stop on the way and rest fixed or motionless as soon as the disturbing force is withdrawn. The experiment of quieting a pugnacious lobster by placing the animal's head downward and gently scratching its back is an instance of the susceptibility to this curious state. Other popular examples of animals sensitive to influences of this kind are witnessed in the so-called charming of birds by snakes or by cats, and in the boyish trick of causing a chicken to remain for some time in a fixed position with its head on the floor after opening the bird's mouth and drawing a long chalk mark in front. Ascending the biological scale, vivisection demonstrates that certain animals deprived of the cerebral hemispheres and motor ganglia retain the most abnormal position in which they may be placed, although the joints remain flexible; and if a part of the body be mechanically irritated, the animal will jump forward with precipitate movements and retain immovable the last-assumed position when arrested by an obstacle. Cataleptic conditions are reported to have been observed in dogs and in horses; but the reporters omit to mention whether the excurvature of the spine and the immobility of the limbs noticed in these animals was or was not accompanied by the passivity and waxen flex-

ibility that are pathognomonic of the disease in the human species.

Since the days of prehistoric medicine the cataleptic state has been for pathologists a nosological oddity, a sort of enigma, and a satisfactory solution still awaits the advance of neurological science. Ancient physicians, knowing but little of the intimate nature of the malady, resolved the question of its supernatural or physical origin according to the principles and knowledge of each century, and characterized the disease by expressive names indicating the outward sign that most attracted attention; this one loss of speech, that one abolition of the senses, another suspension of voluntary motion, there being as many definitions as authors; hence the prevailing uncertainty, confusion, and incoherency of opinions regarding this interesting subject, and the consequent great variety of definitions and profuse synonomy.

During the Greek period the fathers of medicine in speaking of this affection used the words *κάτοχος*, *κατοχή*, signifying a seizure or a shock. They also expressed the condition by *ἀφονια*, *κωματαύδη*, and *ἀναυδία*, words that express equally absence of speech. The Latin writers used corresponding terms, which in turn were used by the middle-age authors, and even by some of the modern. The word catalepsy has, however, definitely prevailed in spite of methodical neologism, and the name is nearly the same in all epochs and in all languages. *Κατάληψις*, derived from *καταλαμβάνειν*, to seize, appears to have beem employed for the first time by Asclepiades of Bithynia, 100 B. C., in his treatise on periodic fevers. This etymology, recalling the kind of seizure that takes possession of the patient at the moment of the crisis, merits preservation for this and the additional reasons that it conveys a mental image, and prejudges nothing of the nature of a disease of which so little is known. Owing to the protean forms assumed by catalepsy, and the presence of frequent complications, not to mention the strange theories advanced by ancient authors, and the comments thereon, it is difficult to define the malady with clearness and precision. But among the more important writers of the present age, whose tendency is to substitute the scientific interpretation of morbid phenomena for the sciolistic rendering of apocryphal knowledge, the cataleptic condition is understood to mean an intermittent neurosis of the cerebro-spinal system, unaccompanied by fever, and characterized by attacks of variable duration, during which there is almost always suspension or perversion of consciousness and of sensibility, and always interruption of voluntary motion, with general or partial tension of the muscular system, and aptitude of animal life to receive and to keep different degrees of contraction impressed on them by extrinsic force or assistance.

To facilitate description, catalepsy is now regarded from two points of view: as a simple or distinct neurosis, and as a symptomatic manifestation common to several nervous affections, notably hysteria, somnambulism, and ecstasy. The two forms may in turn be complete or incomplete, and general or partial. This divergence, ostensibly in the interest of clearness and system, is owing rather to the pathological obscurity enveloping the subject.

Idiopathic catalepsy, as wonderful as it is rare, is an apyretic brain malady manifested by successive intermittent attacks separated by intervals of health. Its special physiognomy is owing to the waxy position of the limbs, and it is the only neurosis in which muscular contractions are possessed with abolition of the will. Either sex may be attacked, and the disease may occur in childhood or occasionally in advanced age; but women are more subject than men, and it occurs mostly about puberty or between the twentieth and thirtieth years, and generally in persons of dull minds and sluggish physical organization. Cataleptic paroxysms may be spoken of as atypical. The fantastic characters of the cataleptic state render all clinical description absolutely obscure; so that the actual observance of a single case, or the study of a series of well-reported histories, will do more to throw light on the question than all the symptomatic enumerations that form the basis of these descriptions.

Systematic observance of cataleptic symptoms relates chiefly to the three orders of pathological phenomena of the mind, sensation, and motion. An attack coming on in a nervous or melancholic individual may be sudden and all the functions of the life of relation appear entirely abolished. There is complete suspension of mental action, with cutaneous anæsthesia, loss of thermic sensibility, and rigidity and inertness of the limbs, which retain the position given to them. This rigidity is described by the old Latin authors in such picturesque locutions as *stipitis* or *trunci instar*, and *mortui ritu jacens*. In some cases the attack may have such precursory symptoms as headache, insomnia, vertigo, hiccough, epigastric pain, a feeling of constriction in the throat, trembling of individual muscles, an undefined sense of discomfort, and different hysteriform nervous troubles. When suddenly attacked the patient remains motionless in the attitude had at the moment when struck. Patients have become cataleptic while drinking tea, playing cards, ascending a ladder, during attitudes of devotion, and the like, and have retained the position held at the time of attack. The various positions a cataleptic may be made to assume have been compared to those of a manikin, to a statue with springs or with limbs of soft wax, which preserve any constrained position or inflexion given to them for a comparatively long period. The muscles of the breast and the inspiratory muscles are unaffected during a cataleptic seizure; and it is probable that the digestive functions go on regularly, although the phenomena of absorption and nutrition operate with extreme slowness. The secretions and excretions are lessened, and even suspended, cataleptics having been known to go for twenty-five days without a voluntary evacuation and to undergo long abstinences, leaving them in the condition of hibernating animals. Consciousness, though mostly abolished, is not so in all cases, the suspension of sensorial function being more apparent than real. With the general disturbance of the vital processes there is almost entire abolition of the functions of special sense. The mucous membrane of the nose, however, retains its sensitiveness slightly, and the act of swallowing may be performed when the substance to be ingested is placed deeply in the pharynx. Reflex irritability is sometimes lost, but the electric contractility of the muscles remains. Respiration is slow and tranquil; the pulse normal in rhythm, though sluggish and at times almost imperceptible. The pupils are dilated, and the fundus of the eye shows paleness of the choroids, with straight and attenuated retinal vessels. The temperature being lowered two to four degrees below the normal, the patient becomes icy cold, deadly pale, and expressionless—a condition that may easily be mistaken for death. In fact, instances are recorded of apparent death from this cause, in which the victim has narrowly escaped being buried alive. The old schoolman, Duns Scotus, is an instance of a resuscitated cataleptic, and a case often quoted is that of a woman who was placed in a family vault, presumably dead, and having regained consciousness during the night, and fortunately finding the vault unlocked, returned home to her husband, and after this strange episode lived to bear a large family of sons and daughters. The event is commemorated by a monument and an inscription in the Lutheran cathedral at Magdeburg; and it is suggested that the possibility of such occurrences may account for the custom that obtains in some parts of Germany of placing a bell above the public receptacles for the dead, and fastening the hand of the ostensible corpse to the rope, that it may be rung in the event of consciousness being regained. An instance is related in France of a cataleptic who was on two occasions the chance victim of hastily rendered funeral honors. Now and then one reads in newspapers of women being taken away for burial while in a cataleptic trance, and only recovering consciousness when being lowered into the grave. Such mistakes could hardly happen nowadays, provided ordinary precautionary measures are taken to discriminate real from apparent death, such as the auscultatory signs, the indications furnished by the thermometer, the electric contractility of the muscles, and the ligature of a finger or a toe.

The attack over, the patient suddenly regains consciousness, sometimes after epistaxis or the appearance of the menses, and there is no recollection of what has happened during the attack. Headache and general lassitude generally follow for a short time. The attack may disappear and be transferred into another neurosis or into a vesania. There is great variability in the number and duration of the attacks, which may last for minutes or hours, or entire months. The malady has been known to disappear after one attack; while in another patient as many as seven hundred paroxysms have been counted. The attacks may, moreover, be very irregular in manner, or they may be periodic, and even occur during sleep. There is no mental disorder in the intervals of simple catalepsy; but when the catalepsy is a symptom of profound nervous disease it may be associated with ecstasy and somnambulism, or the occurrence of hysterical convulsions, delirium, maniacal attacks, and hallucinations. For this reason it is generally held that cataleptics are responsible for their acts during intervals, except where there is a complication.

The condition represented by the picture outlined in the foregoing remarks is often modified or softened down into the incomplete form, which, though not having all the symptoms of what may be called ideal catalepsy, exhibits nevertheless, in a different degree, the motor and sensory disorders, and electrical reactions characteristic of the disease in question.

Catalepsy may be associated with another nervous affection, such as hysteria, ecstasy, somnambulism, tetanus, mania, hypochondria, and lypemania; or with a disorder of an entirely different nature, as pneumonia, typhoid fever, meningitis, rheumatism, intermittent fever, etc. It is complicated and mixed in *hystero-catalepsy*. Without doubt hysteria is the neurosis with which catalepsy affects the most frequent relations and narrowest affinities. As one and the same morbid state they proceed from a common origin, and doubtless are closely related. Muscular rigidity in this form varies as to the degree, not being in positive relation with cutaneous anæsthesia, but almost always proportional to the depth of lethargy and to the volume of the muscles concerned in the movements of the articulations. Persistence of muscular tension, with absence of sensibility and fatigue, are spoken of in connection with this state as a new variety of perturbations of voluntary motility. Systematic writers describe hystero-catalepsy as general or partial, complete or incomplete, and transitory or permanent. In rare cases it is unilateral.

Ecstatic catalepsy has been often observed in ecstatic women and in priests. The annals of medicine abound in instances, historic and modern, of women becoming cataleptic during certain religious observances, of priests who become so at certain stages of the mass, and of monks who throw themselves into prolonged cataleptic ecstasies. No less a writer than Balzac speaks of profound meditation and fine ecstasy as catalepsy in the bud. Doubtless many of the queer sects mentioned by Dr. Hepworth Dixon, in "New America," are made up of individuals whose mental condition is more or less influenced by this disordered state. Anthropologically and pathologically speaking, the same remark would apply to various so-called religious ceremonies that have obtained among all races in the times of all the prophets, from Moses to the Latter-Day Saints of Salt Lake City, and in the worship of all the gods from Jupiter to the latest theosophic misconception; and however much we may respect the courage implied in the expression of a sincere opinion, it is impossible not to detect the further existence of this disordered state as shown in numerous sciolistic writings, notably those of Dale Owen, Swedenborg, and the theosophists. Moreover, it needs but little observation to trace the prevalence of the same morbid influence among clairvoyants, spiritualists, and even the ardent admirers of Madame Blavatsky.

Catalepsy with somnambulism is a complication in which the phenomena of catalepsy and the symptom of somnambulism are bound one to the other, and succeed in a regular order in such a manner as to form a single attack. They are sometimes distinct, independent of each other, and separated often by long intervals.

The disease may occur with other accessories, as catalepsy with tetanus, catalepsy with epilepsy, and with chorea, the chorea happening in the daytime and catalepsy at night during sleep. Catalepsy may also exist with permanent contraction of the feet and hands; with delirium and melancholy, with acute and chronic mania, and with dementia and idiotism. It is a frequent complication of monomania, and is sometimes, though rarely, associated with hypochondria. We may occasionally see in the same subject hysteria, catalepsy, ecstasy, and somnambulism succeed, turn by turn, and mix one with the other, with a frequency entirely out of the regular order of things and an intensity unheard of. This extraordinary mixture of cerebral neuroses was met with in its highest degree in the great convulsive epidemics of the middle ages, during the sixteenth, seventeenth, and eighteenth centuries; and their occurrence having become a matter of history and of common hackneyed observation with writers on kindred subjects, it suffices to give them merely a passing mention. Catalepsy is met with in acute dementia, stupidity, and other non-determined cerebral affections. The cataleptic states may still be manifested in the greater part of the neuroses, and in diverse affections of the brain, and with such acute diseases as pneumonia, typhoid fever, acute articular rheumatism, intermittent fever, and worms. Verminous catalepsy has been noted and commented upon by various writers.

Epidemic catalepsy, like many of the neuroses, may become contagious by imitation under mesological circumstances favorable to its propagation. Such circumstances exist when the disease occurs in an assemblage of impressionable subjects, as a school or a convent, a camp-meeting, or a spiritualistic gathering, where a twofold predisposition is to be found in the nervous temperament and in certain questionable hygienic and moral conditions. In former epidemics, the disease seen in its most startling and complete expression, exhibited a terrible spectacle and mixture of all the neuroses and all the vesanias. It was common for celibate and ascetic persons to show the strangest nervous symptoms; to fall cataleptic at mass or during other religious observances, and to exhibit the complex symptoms of hysteria, demonopathy, and catalepsy.

Catalepsy and cataleptoid phenomena may be provoked artificially in hysterical, or other predisposed, impressionable and nervous persons, through mental suggestion, or by intense light, the sonorous vibrations of a tuning-fork, and by pressure on the ovaries. These artificially induced conditions have been studied by various persons, Braid, Carpenter, Azam, Charcot, and lately by Hammond, of New York, who think the condition should properly be called *syggignostic* (συγγιγνώσκω, *to agree with*), on account of the overwhelming inclination on the part of the subject to agree with the suggestions received from other persons (see Syggignosticism). If, during the syggignostic period, the operator places one of his fingers on the head of the subject and another finger on the face or head, it is said that he produces in all the body of the patient a commotion very like that of a sharp electric shock. It is noticeable as a further characteristic of this strange condition, that if the ideas and action of the operator be directed toward the attitudes, the expression of the feelings, or any determined action on the part of the patient, these feelings and action come to him immediately. On mere suggestion that the body is in a rigid state, the muscles of a syggignostic subject become immediately tense and cataleptic, and a physically weak person in this state may maintain abnormal postures that would prove trying to a gymnast.

The physiological cause of this and of allied conditions is presumed to be inhibitory arrest of activity of certain tracts of the ganglion cells of the brain cortex. It is, however, impossible to say in the present state of scientific observation whether inhibitory lesions exist or not in catalepsy; but it is probable that there is, in addition to muscular inhibition, a morbid element, the essential nature of which is unknown. Such superficial alter-

ations as considerable development of the Pacchionian bodies, and injection of the meninges found after death from catalepsy are insufficient to explain the symptoms during life; and the inflammatory exudation or alterations found in the central organs, with softening of the optic thalumus and corpus striatum, are lesions rather to be associated with other diseases than with catalepsy, since they were present as complications in the observed cases; therefore, until something more complete is known of the morbid anatomy of catalepsy, it must be regarded as the result of a purely dynamic lesion of the cerebrospinal nerve-centres manifested chiefly by syggignocism and muscular rigidity.

If the pathological nature of catalepsy is obscure and unknown, its causes are extremely numerous, and present a particular interest. Nervous exhaustion is the most common predisponent, and of all the etiological moments hysteria is the most prominent. Acquired or innate predispositions are found in persons of great nervous susceptibility and unsteadiness, or in those of a nervous and melancholic temperament with a previous neurosis, and rendered more susceptible by chlorosis, masturbation, or progressive spinal paralysis. Tumors, tubercular meningitis, and other chronic cerebral diseases, may also give rise to cataleptic manifestations. Atavistic influences seem to account for some cases of catalepsy. It does not appear, however, that the disease is ever directly transmitted.

The causes that may provoke a cataleptic crisis are numerous and varied, and it often follows diverse circumstances, as excess of work, religious excitement, violent fright, deep chagrin, an attack of anger or indignation, gastro-intestinal irritation, sudden cessation of the menses, unrequited love, and worms. It may result in a transitory form from diffused encephalitis, or as one of the sequels of typhus or of malarial fever. Partial catalepsy may also be in consequence of the narcotic inhalation of ether or chloroform, of poisoning by lead or carbon dioxide, and it may result from being struck by lightning. Everything, in fact, that is capable to agitate or make an intense impression on the brain may provoke catalepsy. The production of cataleptic crises, by looking fixedly or for some time at a bright object, and vividly riveting the mind on the image is one of the proceedings of Braidism or Mesmerism. Among the hack observations of medical writers are those relating to the Franciscan friars, who became cataleptic at mass during the elevation of the host. It is known that the monks of Mount Athos go into a state of cataleptic ecstasy by looking fixedly at the umbilicus; Indian fakirs fall into catalepsy by looking a quarter of an hour at the end of their nose; Egyptian sorcerers procure sleep and insensibility by similar details; Arab sorcerers of Cairo, by looking steadfastly into the palm of the hand; and it is related of Cagliostro that he brought on somnambulic crises by similar means. Instances of psychic shock, like that of a woman who became cataleptic every time she saw a certain man who had insulted her, or that of an indignant French judge, who suddenly became cataleptic when insulted in court, incline one to the opinion that such expressions as "petrified with indignation," "motionless with surprise," and the like, though merely implied comparisons, are not always to be taken in the metaphorical sense.

The marks that constitute the essential and pathognomonic characters of catalepsy, as aptitude of the limbs to preserve during a relatively long time the position given to them, and the impossibility of the patient to modify this attitude, along with unconsciousness, anæsthesia, and analgesia, should make the matter of diagnosis easy. Embarrassment is most likely to occur in cases of simulation, or when it is a question of discriminating between hysteria, tetanus, ecstasy, coma, lethargy, syncope, congelation, or cadaveric rigidity. In the matter of simulation it is only necessary to test the sensibility, the reflex irritability, and the electrical contractility of the muscles, and to try the influence of mental suggestion. In cases associated with hysteria the distinction is a matter of no therapeutic importance. The general history of the case should cause no confusion in diagnosing catalepsy from the affections with which it may be associated.

Many regard catalepsy as the index of a predisposition carried to a high degree and by itself not dangerous to life, but a disease in which recoveries are rare. Some recent authorities think otherwise in regard to the prognosis, and Hammond pronounces it favorable even in severe cases, as all his patients recovered under treatment. In cases resulting from malarial infection the prognosis is better. The same may be said of acute attacks resulting from injury, from worms, or from mental shock in comparatively healthy persons. The retention of smell and taste is indicative of returning health. It is only in cases of complication that death occurs. This may be in consequence of anæmia or of inanition.

To arrest an attack of catalepsy efforts may be made to arouse the patient by peripheral irritation, as that caused by a pinch of snuff, or the inhalation of a few drops of amyl nitrite. Quinia and morphia in combination are recommended in periodic cases of malarial origin, and vermicide remedies are called for in catalepsy caused by intestinal parasites. Tonics, iron, ergot, and apomorphia hypodermically—one-twentieth of a grain—have all been recommended. The most efficacious medical treatment yet reported consists in the administration of one of the bromides in combination with zinc oxide, and the simultaneous use of strychnia and other tonics. Acupuncture, faradic electricity, hydrotherapeutics, and change of air, are useful adjuncts to the treatment. In addition to meeting symptomatic indications, moral hygiene of the most rigid kind should be enforced, and it is of prime importance that all emotional excitement be avoided. The mind should be disciplined; home influences are to be broken up; and every effort should be made to establish the general conditions of health, which must prevail before the morbid action can really be effaced.

Irving C. Rosse.

CATARACT is the morbid impairment of the transparency of the crystalline lens, or of its enclosing capsule, and is lenticular or capsular, according to its situation. A less important division is that into true and false cataract, the latter being caused by deposits on the capsule, the result of disease.

Cataract may be stationary or progressive, partial or total. It may be cortical or nuclear, according as it affects the cortical substance or nucleus of the lens. When confined to the vicinity of either pole it is denominated anterior polar or posterior polar, in conformity with its position. The old division into hard and soft is rarely used at the present day, the consistency of the cataract largely depending on the age of the individual. Cataracts are moreover divided, according to the stage of development in which they are encountered, into incipient, mature, and hypermature. Finally, they may be classed as simple or complicated; as simple when dependent on or associated with no known disease, either local or general; as complicated when proceeding from an affection of the system at large, such as diabetes; or, from an impairment of the eye itself, like glaucoma or separation of the retina.

DIAGNOSIS.—*Objective Symptoms.*—The modern methods of investigation render the diagnosis of cataract a matter of certainty. By their aid the slightest opacity of the crystalline lens can be detected and correctly located, and they have wholly superseded the old "catoptric test," which depended on the reflected images from the anterior and posterior capsules, and the disappearance of the latter when opaque substance intervened before it. Recourse is now had to the concentration of light on the eye by means of a convex lens, and to the illumination of its interior by means of the ophthalmoscopic mirror. In either case the pupil should ordinarily be dilated by the application of one of the usual mydriatics, duboisine, homatropine, or atropine. The first of these acts with the most rapidity, the second produces the most temporary effect, while the third is the one most generally accessible.

The pupil being dilated, and the rays of a lamp, placed thirty to fifty centimetres from the patient's head, con-

centrated obliquely on the crystalline by means of a convex lens of short focus, 18 D. to 15 D. (2 to 2½ inches focal length), any capsular and many lenticular opacities are rendered plainly visible. A second lens, held before the observed eye, may be used to magnify their distinctness. But it is necessary to bear in mind that, with advancing years, the outlines of even a normal crystalline lens assume increased distinctness. Its anterior surface takes on a silky lustre, the fibrous structure becomes more and more visible, while age gives the nucleus additional density and a yellowish reflex that may often prove deceptive. No absolute diagnosis of cataract must be based on the appearance of a grayish cloudiness in the centre of the pupil, until the ophthalmoscope has been brought to bear on the spot. In this method of examination the mirror is alone used, being held at about the reading distance of the observer from the patient's eye. The vivid red of the illuminated pupil remains unbroken when the media are clear, and the returning light traverses a transparent crystalline. When, however, this is not the case, the smallest opacities are distinctly seen as dots, shadows, or stripes against the bright background. Their precise situation is made out when the observer moves his own head to one side, opacities situated in the front of the lens moving in the same, those at its back in a reverse direction. The differential diagnosis between lenticular and other opacities of the transparent media is easily made, corneal spots being distinguished by oblique illumination, floating bodies in the vitreous by their mobility.

So great is the danger of mistaking the reflex from the pupil, due to advancing age, for cataract, when the examination is made by day and with the unassisted eye, that a diagnosis should rarely be made until both methods here described have been employed.

Subjective Symptoms.—When an individual who has passed middle life begins suddenly to grow near-sighted, to see distant objects better through a concave glass, and to lay aside his usual reading-glasses, or even to require a weak concave for this purpose, commencing cataract may be suspected, and this even when no opacity of the crystalline is as yet visible. This state of the refraction is by no means invariable, but happens with tolerable frequency, and explains some of the cases of "second sight," or the returning vision of the aged, a popular belief in which is so widely spread. Much more general is the occurrence of multiple vision with a single eye. The patient sees several new moons in the sky instead of one, and the flames of the street lamps are no longer clearly defined, but seem to shoot out long rays in all directions, or else several lights are seen in the place of one. The lens, in these cases, seems to undergo a separation into sectors, possessing different powers of refraction, prior to becoming the seat of actual cataract. As the disease advances the acuteness of vision falls off. At first near, and later distant, objects are distinguished with increasing difficulty. Points of light loom up as if seen through a fog. A characteristic symptom is the change produced in the appearance of objects by varying degrees of illumination. In the majority of cases the cataract patient sees best before sunrise, after sunset, when the sky is overcast, or on a dull day. He is confused and blinded by a sudden increase in the amount of light around him, such as would be caused by the sun emerging from behind a cloud. The use of a mydriatic renders him to some extent again independent, and atropine may thus often be employed with advantage to eke out and prolong vision that is being reduced from this cause, and where the opacity of the lens will be found to be mainly central. In the rarer cases, in which obscuration commences at the periphery, enlargement of the pupil exposes the imperfect portions of the crystalline, and causes a disturbance of sight. Such patients see best through a contracted pupil, and instinctively crave an excess of light.

Diagnosis of Maturity.—As the success of the operation for cataract is always greatest in cases in which the disease is fully formed, the question of ripeness becomes an important one, and may easily be settled. Oblique illumination should show the lens to be opaque up to its front. No layer of transparent substance is to intervene immediately behind the pupil. When the cataract is mature the iris is seen to be in direct contact with the opaque lens, and the edge of the pupil throws no shadow when the source of illumination is moved a little more to one side. In addition to all this, however, it is important to ascertain that each anterior chamber is of equal depth, that the iris of the eye affected with cataract is not bulged forward beyond the plane occupied by its fellow. For such bulging indicates the lens to be in what is called the "period of swelling." Just before the opacity of the cortical substance becomes entire, its fibres often appear to swell and separate, the lens grows apparently larger and presses forward, frequently restricting the motions of the pupil. In time this process recedes, the lens loses in volume, and its mass becomes more compact, thus offering a more favorable opportunity for the operation of extraction. The period of swelling should therefore ordinarily be allowed to subside.

Functional Examination.—It is hardly necessary to dwell on the fallacy of the popular notion that, in a case of cataract, blindness must occur before the operation becomes admissible. Many a patient, misled by this belief, has waited until the last perception of light had died away, and then presented himself to the surgeon for treatment, to be met with the announcement that the disease was not cataract, and that treatment had only been possible while some vision remained. An opaque lens merely interposes a screen, more or less translucent, to the passage of light, an appreciable amount of which still filters through. Where no perception of light remains, therefore, no restoration of sight is possible. The patient must be able to make out not only the presence, but the position, of a luminous object. Having ascertained, by covering the other eye, that the one affected has a general perception of light, that the pupil expands and contracts in accordance with the degree of illumination, and that the position of a window can be pointed out, it is well to test more carefully the sensitiveness of both the central and the lateral portions of the retina. The patient is taken into a dark room, the good eye carefully covered, and the gaze of the other fixed in a given direction. This may be brought about by desiring the patient to hold up one of his own hands, at arm's length, on a level with his eye and straight before him, and directing him to look persistently toward the spot where he knows this hand to be. A lighted candle is first held as close as possible to the hand he is fixing, and then moved in the same plane up, down, and to either side successively: the patient being required to indicate each new position of the candle, without removing his eye from the direction of his own hand. If he sees the light each time its position is changed, it is certain that the whole extent of the retina retains its normal sensitiveness; if he fails to observe it in one direction, the powers of the retina are correspondingly impaired. When the light, on being moved upward, can no longer be located, the lower portion of the retina is destitute of perception, and it must be borne in mind that here is the usual position of a retinal separation. When he sees the light laterally, but not straight before him, the region of the macula lutea is generally diseased, and the power of reading is unlikely to be regained, even after a successful operation.

Causation of Cataract.—Our knowledge on this point is extremely limited. Becker's[1] researches go to show that senile cataract originates in an interruption of the progressive sclerosis of the lens. Attacked with this disease it shows in the outset a decided contraction of volume. The cortical substance is thus, as it were, split up. The intervals thus left are at first filled with the normal fluid, the index of refraction of which subsequently changes, thus making the divisions more plainly visible by transmitted light. Actual opacity now begins to occur, the fluid constituents of the lens increase, and its volume augments. The microscope shows changes in the fluid, molecular opacity, and swelling in the fibres; the places of which latter in the cortical are subsequently occupied by the products of degeneration.[2]

But all this brings us no nearer the cause of cataract. It is broadly stated that it is due to an impaired nutrition

of the lens. This merely gives the difficulty another name. How is this nutrition effected? The crystalline body possesses neither nerves nor vessels, is suspended between two fluids, the aqueous humor on one side and the vitreous on the other, each similarly devoid of vessels, and probably in some way receives its nourishment through them. That substances introduced into the general circulation may ultimately be detected in the lens has been shown by experiment, although a considerable interval must elapse before their arrival occurs. They are supplied to the aqueous and vitreous by the vessels of the surrounding parts, and through them to the lens itself. Impaired nutrition of these two humors may therefore indirectly be the cause of cataract.

It is certain, on the one hand, that there must be some predisposition in the system at large, as senile cataract almost invariably attacks both eyes, although at different periods. It is equally certain that there must exist some local, modifying factor, inasmuch as the most diseased eye is always first attacked. This statement is based on the well-known fact that the prognosis in the second eye is usually better than that in the first.

VARIETIES OF CATARACT. — *Congenital.* — These are either partial or total, more generally the former, occurring in the shape of sharply defined opacities. It may in general be said of cataracts of this class that they are the result of defective formation, and are accompanied by a certain amount of amblyopia or imperfect perception; which not only persists after the mechanical obstruction to the entrance of light is removed, but is apt to increase with advancing years, if the eye be left alone, thus rendering advisable the early performance of the operation. Very different in this respect is senile cataract, which may last without impairing the functions of the retina behind it.

1. *Zonular Cataract.*—This may be either congenital or met with in the earliest years of life, and is, according to Graefe, the most frequent of all the forms occurring in childhood. A central zone or shell of the crystalline is affected, circular in shape, surrounding and surrounded by entirely transparent lens substance. Seen from the front, by oblique light, or through the ophthalmoscopic mirror, it appears like an opaque or partially opaque nucleus to an otherwise transparent lens; and closer examination reveals its own centre to be transparent. Its diameter ordinarily varies between five and eight millimetres. Sometimes this layer is surrounded externally by a second, equally opaque; sometimes, instead of a complete layer, groups of opaque points or striæ are irregularly distributed, with large intervals of clear lens periphery between them. In many cases the whole volume of the lens has suffered diminution. Zonular cataract is invariably met with in both eyes. It is frequently found that the children in whom it occurs have been the subjects of convulsions. They are, also, sometimes the victims of rachitis. This disease of the lens, when congenital, generally occupies a lesser area at birth than subsequently, and is hence often overlooked in very early life. Its subjects may be recognized by the way in which they shade their eyes to get the advantage of a dilated pupil, going into dark corners to thread a needle or perform some task requiring more than usual eyesight. And, in this connection, although the various operations for cataract will be described at a later period, let it here be said that the relief afforded by a dilated pupil indicates the operation for zonular cataract, which should never be treated by the removal of the lens. The formation of an artificial pupil (see Iridectomy) opposite a transparent portion of the periphery, gives a permanent opening for rays of light to reach the retina unobstructed; is rapid in its effect, and far less likely to be followed by inflammation than the operation for absorption or extraction. Even a successful operation of the latter kind entails the use of at least two pairs of heavy cataract glasses for life.

2. *Punctated cataract* consists in a large number of extremely small points of opacity, scattered throughout the lens. At the anterior and posterior poles they are often grouped into a triangular figure composed of short lines, meeting at an angle of 120 degrees. The figure at the anterior pole has not the same direction as that at the posterior. Under strong illumination the opacity takes on a bluish tint. Examined under a high magnifying power, these opaque points present the appearance of small round or oval drops. Their form and position encourage the belief that they are situated, not in the lens fibres, but in the interfibrillar substance. According to Liebreich,[3] from whom the above account is borrowed, this form of cataract is frequently, perhaps, indeed, generally, overlooked.

3. *Anterior Polar Cataract.*—A small, round, brilliant, white point, sometimes attaining a diameter of 2 to 2.5 mm. may occupy the centre of the anterior pole of the lens. At times it projects forward into the anterior chamber, and is then known as pyramidal cataract. Often there is a faint central corneal opacity in these cases, and then, according to Arlt, the rationale of the formation of this kind of opacity becomes evident. An intra-uterine central ulcer of the cornea is followed by perforation, the aqueous escapes, the lens comes forward into contact with the cornea, and a portion of the exudation, caused by the ulcer, adheres to the anterior capsule. When the ulcer heals and the anterior chamber is re-established, the lens recedes to its original position, carrying with it the acquired opacity. It is contended by some observers that simple corneal inflammation, unattended by perforation, may also act as a cause.

4. *Posterior Polar Cataract.*—This is a stationary opacity, rarely as small as the smallest examples of the kind just described, situated at the posterior pole of the lens. Its outline may be round and defined; or it may send out striæ of opacity in different directions. It will generally be found to be associated with a persisting hyaloid artery.

5. *Total Congenital Cataract.*—This may differ in no respect from the soft cataract of the young, which is next to be described. But it is more frequently liquid, or else shrunken, and is very apt to be adherent to the iris. The capsule in such cases may be abnormally thickened. These cataracts are always double, and very frequently hereditary.

Soft Cataract of the Young.—The nucleus of the lens is rarely defined before the thirtieth year. Between thirty and forty there is, in the majority of cases, a small nucleus. After forty it is seldom absent. Cataract occurring in a lens devoid of nucleus is always soft. It commences sometimes in the shape of a general grayish opacity, at others in the form of points or long striæ, in the external cortical layers, and advances with comparative rapidity until the whole lens becomes clouded. It is in this form of cataract that the swelling of the crystalline, already alluded to, is most marked; the iris during this stage being thrown well in advance of its normal plane, and the movements of the pupil becoming restricted in comparison with those of the other eye. An operation at this time is apt to be followed by iritis, and should hence be avoided. Entire liquefaction may subsequently take place, the whole of the lens taking on the color of milk, or of milk mixed with water. As has been said, soft cataract may develop very rapidly. It may, moreover, be confined to one eye, and depend on either a general or a local cause, the nature of which may readily be determined. An example of the first is the

Diabetic Cataract.—As the soft cataract of early life is so often confined to one eye, the simultaneous affection of both lenses at this period would lead us to suspect a constitutional origin, particularly the existence of diabetes mellitus, and to examine the urine for sugar. This form of cataract may occur at any age, and, in the case of the young, progress with great rapidity. It resembles other cases of soft cataract in all respects, except that, according to some observers, traces of sugar are to be found in the lens. The prognosis of the operation is, of course, somewhat modified by the presence of so serious a disease, but need not necessarily be regarded as unfavorable, many cases making a rapid and uncomplicated recovery of sight. It has been claimed[4] that the use of the waters of Carlsbad has been observed to arrest diabetic cataract, and even to cause its complete disappearance.

Cataract Occurring in Connection with Separation of the Retina, Retinitis Pigmentosa, or Disease of the Choroid.—Here we have undoubtedly to do with a local impairment of nutrition. And, of all these causes, the former is the most frequent. The cataract exhibits no peculiarity of appearance; its cause must be inferred from the fact that it is monocular, that the vision of this eye had been considerably impaired before its appearance, and from the functional examination which reveals a diminished or extinct perception of light in one part of the field, generally the upper. In retinitis pigmentosa the opacity commences as a round spot at the posterior pole of the lens, from which radii shoot out toward the periphery. The anterior portion of the lens subsequently becomes similarly affected, but total opacity does not occur.

Traumatic Cataract.—The transparency of the lens depends on the integrity of its investing capsule. This may be ruptured by a contusion of the eye, or wounded by the penetration of a foreign body or of a sharp instrument. The aqueous humor then comes into immediate contact with the lens, which imbibes it, swells, and becomes opaque. When the capsular wound is very small it may again close, and the opacity remain confined to the contiguous portion of the lens. But more frequently the swollen cortical substance protrudes from and itself widens the capsular wound, thus exposing fresh portions of the lens and ending in its general obscuration. As they protrude into the anterior chamber these masses may be absorbed, and finally the whole cataract thus be removed. But more generally, unless the pupil be at once artificially dilated, the pressure takes place against the iris, which inflames and renders necessary the operative removal of the opaque body.

Senile Cataract.—Under this form we understand the opacity of the cortical substance of a lens, the nucleus of which, with advancing years, has both separated and hardened. It is necessary to a proper understanding of the subject to bear in mind the probability that only the cortical layers become actually opaque, and that there is no essential difference, in the transparency of the nucleus, between the eye of an aged person who has always had good sight, and the eye of one who has become blind from senile cataract.[5] No precise age can be assigned as that at which this form properly begins, so much variation is there in different individuals as regards the separation and hardening of the nucleus. In general it may be stated that senile cataract is most apt to occur after the fiftieth year. Testing the transparency of the crystalline, in people who have passed this age, the observer is often struck by the appearance of a series of short bifurcating linear opacities, ranged around the periphery of the lens. They may be the most numerous in either the upper or the lower segment, or even extend around its entire periphery. The practical point concerning them is that, though their appearance is always to be regarded as suspicious, they are not necessarily an indication of advancing cataract. They may either remain unaltered for years, or they may increase at once in number and extent. In the former case they are simply a senile change, analogous to the arcus senilis of the cornea; in the latter they justify the diagnosis of incipient cataract. They must be carefully observed, and the patient is not to be alarmed with a positive diagnosis of disease unless they are found to be increasing.

Becker[6] gives the *résumé* of the various stages of senile cataract and their proper nomenclature. As long as there are a few opaque striæ discernible in the periphery only, or in exceptional cases before or behind the nucleus, we speak of incipient cataract. If the opacity of the cortical substance has advanced, the expression unripe cataract is used. There is no absolute line to be drawn between these two, save that the cataract is to be regarded as incipient so long as the greater part of the cortical substance is transparent; as unripe when opaque cortical prevails. When the opacity of the cortical is complete the cataract is designated ripe. Oblique illumination then reveals no transparent portion, and no red reflex appears when the ophthalmoscopic mirror is used. The posterior portion of the lens is now, of course, invisible, but it ordinarily keeps pace in these changes with the anterior, and may be assumed to be in the same state.

Senile cataract generally affects both eyes, but is developed later in one than in the other. The fact that the eye last affected furnishes the better result has already been alluded to. That the tendency to this disease is hereditary has been abundantly demonstrated. The popular notions that the left eye is more apt to be first affected than the right, and that more men than women are the subjects of cataract, rest on no reliable foundation

Absolute maturity of the senile cataract is not always to be waited for, or indeed, invariably expected. In certain cases the complete affection of the cortical progresses with extreme slowness; vision in each eye may have fallen off to such an extent that reading and writing are no longer practicable, and the patient even finds it impossible to go about alone in strange localities, or those with which he is imperfectly familiar. Failure of sight continues to progress, but can only be made out with certainty by comparing the vision at long intervals of time. Meanwhile age creeps on and the general health, affected, perhaps, by both moral and physical causes, commences to give way. In other cases progress in the formation of the cataract comes to an absolute standstill. The sclerosis of the nucleus may be complete, the cortical partially opaque, admitting a considerable red reflex, or perhaps even an imperfect view of the fundus to the ophthalmoscope, and months and perhaps years elapse without any change in this condition of things. Ripeness is here evidently not to be expected, and surgical interference, either directly or after the operative production of maturity, is wholly justifiable.

Black Cataract.—This name is applied to those rare cases in which the sclerosis of the nucleus goes on uninterruptedly and extends up to the capsule. Although occupied by a ripe cataract, the pupil appears black, even when oblique illumination is used. Cortical substance is completely wanting, and the whole lens converted into one hypertrophied nucleus. This condition is of most infrequent occurrence.

Capsular Cataract.—Deposits on the capsule from without have already been alluded to. Primary affections of the capsule itself, the formation of opacities in its proper substance, are extremely rare. They are to be looked upon as the result of lenticular inflammation, and imply some further disease of the eye. Opacity of the lens substance itself is apt to ensue. But capsular cataract ordinarily occurs as one of the changes consequent on hypermaturity of an ordinary cataract.

Final Changes in an Over-ripe Cataract.—Inflammation in the lens, caused by this state of things, may bring about the formation of capsular opacities. The cortical substance may undergo partial absorption, this producing some improvement in vision, and leading to a diminution in size of the lens. It may become liquid, and the nucleus, no longer supported, may sink to the bottom of the intracapsular space. The capsule sometimes thickens and becomes studded with crystals of cholesterine. The whole cataract may become cretaceous, or under very exceptional circumstances, even osseous. In the former case extensive adherences with the iris may exist.

TREATMENT OF CATARACT.—*Medical Treatment.*—In view of the great advances made in the diagnosis and treatment of diseases of the eye during the present generation, as well as of the earnest efforts that are still being made in all directions to further opthalmological science, it would indeed be hazardous to assume that no local application or general medication to affect the progress of cataract will ever be discovered. None the less must it be firmly asserted that, at the present day, we possess no means whatever of preventing the formation of the disease. Numberless remedies have been tried in the past, but have all proved inefficacious, and at the present day none but charlatans assert their ability to cure cataract without an operation. Some administer nostrums, others make topical applications, while others again extol the virtues of electricity; the result in every instance being the same. If the cases of reported cure be thoroughly sifted, it will be found that by far the larger

proportion are based on a mistaken diagnosis; that in many instances the process has simply come to a standstill; while in a small number of eyes the lens has either undergone spontaneous dislocation, or else the swelling of the crystalline has been so unusually great as to rupture its capsule and lead to total absorption. Opacities of the layer of intracapsular cells may wholly disappear, and traumatic cloudiness of a portion of the lens may regain some degree of transparency. It is also a well-known fact that diabetic cataract may vary directly with the progress of the disease.

2. *Surgical Treatment.*—This consists in reopening a path for the rays of light to reach the retina, either by the side of the existing obstruction (iridectomy) or by its absolute removal. The latter may be effected in one of three ways: The cataract may be left in the eye, but be pushed aside from the axis of vision (reclination, depression); it may be caused to undergo absorption by being brought in direct contact with the aqueous humor (discission); or it may be bodily removed from the eye through an opening made for the purpose (extraction).

General Considerations.—The indication for an operation for cataract is a probable improvement in vision, combined with safety to the general health of the individual. The two preliminary questions, therefore, to be settled are, first, as to whether a careful examination of the condition and functions of the eye renders it likely that the cataract can be successfully removed; and second, whether the general health is likely to be injuriously affected by the excitement attending the operation, or the subsequent confinement that may be necessary.

As a rule it is undesirable to operate on a teething child, a pregnant woman, or one who is menstruating or about to do so. The general condition of the patient should be carefully inquired into and the prognosis modified if any general disease like diabetes or Bright's disease be present, and it is yet deemed desirable to proceed with the operation. If the patient is fresh from a journey, a day or two's rest should be allowed. If the operation takes place away from home, a sufficient time should be afforded the individual to familiarize himself with his new surroundings. On the Continent of Europe there is quite a general agreement among ophthalmic surgeons that serious operations, like the extraction of cataract, which entail a lengthened convalescence, should be performed away from home; generally in the private rooms attached to the hospital with which the surgeon happens to be connected. An establishment especially arranged for the purpose offers advantages of light, ventilation, quiet, and skilled attendance, with which no ordinary private house can compete. There is, moreover, a freedom from care and anxiety that can rarely be secured at home. For the first day or two, relations and friends being excluded, there can be no allusion to exciting topics or consultation on household cares. Distance from the latter is found to induce, with the head of a family, a feeling of repose that close proximity would go far to destroy.

The long-received notion that the spring and fall are the best seasons for cataract operations was undoubtedly based on the fact that these were the times of year which the peripatetic oculists, who formerly infested the community, found most convenient for travelling. In the United States the extreme heat that may prevail during the months of July, August, and September might exert an unfavorable effect on a protracted convalescence, and therefore renders these months less eligible than those in which the weather is generally cooler.

Should one eye be operated on when the other is entirely normal? Assuming the cataract to have been successfully removed, there are certain undeniable advantages in the association of such an eye with a normal one. Although the lens is wanting and the refraction of the two eyes thus radically different, binocular vision is often enjoyed. When this is not possible, double vision does not necessarily arise, as the patient learns to abstract from the image furnished by the imperfect eye, and to rely on the sound one for accurate perception. Even then he has a larger visual field than if he had only one eye, a better estimation of distance, and appreciation of solidity. He is no longer blind on one side, and, when moving about, avoids accidents to which he would otherwise be liable. With the young, therefore, such an operation is always to be encouraged, both for these reasons and, in the case of females, for those of a cosmetic nature. But with the aged different considerations must prevail. The operation, with them, is neither as simple nor as safe, and the after-treatment is much more prolonged. The interruption in the usual habits of an elderly person, the shutting them up in a dark room, changing their diet, and depriving them for a fortnight of the air and exercise on which they are dependent, may exert a serious influence on their health. While in youth it is, therefore, advisable to operate on a single eye, the maxim in age should be never to touch a cataract on one eye until the other begins to be affected, and then to delay as little as possible, bearing in mind the fact that the longer the operation is deferred the older the patient is, and the greater the depressing effect exerted on his morale by impending and advancing blindness.

Patients are often encouraged by their home advisers to wait until both eyes are fully affected, in order that both may be operated on at the same time. While the simpler cataract operations may undoubtedly, under ordinary circumstances, be performed in the young on each eye at one time, without incurring unwarrantable risk, the extraction of senile cataract on both eyes simultaneously is unjustifiable, save in the most exceptional cases. And this for the following reasons: If one eye only be operated on, the symptoms which follow, and the way and manner in which the eye rallies from or, in extreme cases, sinks under the violence inflicted on it, guide us materially in what we are to do for the other eye, and teach us to adopt such precautions, or to so modify our method, as to give the patient a better chance of sight, and to save him from the dangers to which our ignorance of his idiosyncrasies exposed him the first time. Again, a patient or his attendants, being little used to such delicate operations, may be imprudent, transgress our positive directions, and consequently lose the eye. If both eyes have been operated on, his only chance is gone. If, however, one only has been touched, he will learn wisdom by experience, and ensure success by being more careful the second time.

It is true that the refusal of the surgeon to operate on both eyes at the same time often practically results in but a single operation being performed. After the confinement of a fortnight in a darkened room the average patient may well shrink from a repetition of his experience, or fear its effect on the general health. Many people have not the time to give to the second operation, or the power of meeting its attendant expense. These are, however, minor considerations, and are not to be weighed in the balance with those which have been brought forward to show the superior safety of operating on but one eye at a time, in all cases of senile cataract.

The Result of the Operation for Cataract.—In the most favorable cases the obstruction may be entirely removed from the axis of vision and full sight be acquired, its acuteness being quite equal to the normal standard. Under such circumstances all the eye has lost is the power of accommodation, which must be met by the use of glasses of different strengths for different purposes, or by shifting the interval between the glass habitually worn and the eye.

But not always is the result thus successful. Portions of the lens may remain behind in the intracapsular space, clots of blood may be imperfectly absorbed, or inflammation cause a proliferation of opaque substance on the face of the capsule; the whole sometimes becoming more or less adherent to the edge of the pupil. This forms what is known as secondary cataract, and demands in its turn an appropriate operation, or the loss of the eye may be entire, the inflammation following the original operative interference being so violent as to cause entire opacity of the cornea, or even wasting away of the eye itself. An irritable stump, thus left, may give rise to sympathetic ophthalmia of the remaining eye, a condition

of things which may also be brought about by the antecedent inflammation. This result is fortunately extremely rare, and may not once occur in the experience of a lifetime.

Discission.—In this operation the removal of the cataract is sought to be effected by wounding the anterior capsule, and bringing the aqueous humor in direct contact with the lens; the object being to cause its complete absorption, without impairing the transparency of its capsular envelope. The former object will not be attained if the consistency of the cataract be too great, its sclerosis too marked. The latter cannot be secured if the operation be followed by serious inflammation, due to the excessive effect produced by its performance, and which would follow a want of care in proportioning the size of the opening in the capsule to the amount of toleration the eye is capable of exhibiting.

The substance of the lens, brought into direct contact with the aqueous humor, imbibes it just as a sponge soaks up water. Like the sponge it swells, and then slowly crumbles away and dissolves. It is the tendency to swell, and thus exert mechanical pressure on the contiguous parts, that constitutes the main danger of the operation; and it is the merit of Graefe to have first insisted on the necessity of proportioning the opening in the capsule to the amount of lenticular swelling the eye can safely sustain. The rapidity of absorption depends on the age of the individual, being most active with the young. The amount of swelling varies according to the maturity of the cataract and the period at which it is attacked.

The course of normal absorption is as follows: First the edges of the capsular wound retract. Then the lens substance begins to swell and protrude into the anterior chamber. Oblique illumination brings it into relief as a grayish plug, blocking the opening left by the needle. In some cases the whole lens gradually swells and presses forward, until the anterior chamber is completely blocked; in others the process is more gradual, and each successive protrusion slowly undergoes absorption. It first grows larger, then more transparent, next its surface becomes irregular, is gradually eaten away, and the mass finally disappears. Sometimes small fragments are successively detached, fall down, and are dissolved. One mass succeeds another, protrudes, and goes through the same process, until the whole lens has been removed.[7] It is evident that the aqueous humor that accomplishes this task is too insignificant in amount at any one time to do more than a small portion of it, and must hence be steadily undergoing both excretion and renewal. As will be seen later on, Arlt bases on this fact a recommendation to hasten absorption, in cases in which it is progressing with unusual slowness, by occasionally doing paracentesis of the anterior chamber, and thus artificially removing the saturated aqueous.

We have thus traced the course of an operation followed by normal absorption. But all cases do not progress thus favorably. The lens may imbibe the aqueous humor too freely, and swell with a rapidity that causes destructive pressure to be inflicted on the surrounding parts. The pupil may then be seen to contract, the ciliary redness that naturally is present in some degree during so active a process as absorption, becomes alarmingly great, and even conjunctival chemosis may ensue. The iris becomes discolored, the eye waters, intolerance of light is felt, local pain becomes severe, radiating in every direction, and finally, unless proper measures of relief are taken, vision may gradually be extinguished by the development of secondary glaucoma, the legitimate consequence of the great increase in pressure. As has been observed by Graefe, these symptoms are almost exclusively met with in the young, the lens in elderly people rarely imbibing aqueous humor so rapidly, or to such a dangerous extent.

To avoid iritis caused by direct pressure of the swollen cortical mass on the iris itself, it is most necessary that the pupil be fully dilated before the operation, and kept so during the whole of the absorption. An important contra-indication to the performance of simple discission is therefore the failure of the pupil to respond to the action of a mydriatic. Cases in which the pupil cannot be readily and largely dilated are not those in which the performance of a simple discission is at all admissible, and this test should always be employed before deciding on the character of the operation to be selected.

This operation is admissible in all simple lenticular cataracts of early life, up to the twenty-fifth or thirtieth year. It is especially to be employed in the case of infants, both because the size of the opening in the eye is so trivial as to obviate the necessity of attention to the healing process, and because at this age absorption takes place with such rapidity that the pressure of the swollen cortical mass is but little to be dreaded. It is also advisable to do discission in lamellar cataract that occupies so large an area as to render an iridectomy useless, and where the patient has not passed the age of twenty. In the traumatic cataract of early life, where the extent of the original injury has been so limited as to produce an effect but slowly progressive, this operation may be used to hasten ripeness of the cataract, and to promote rapidity of absorption. For nearly a generation it has been justly abandoned in all cases of senile cataract.

Instruments; Preparation of the Patient; Method of Operation.—The instruments needed for the performance of discission are the ordinary spring speculum, fixation forceps, and stop-needle. The latter (Fig. 572), the perfection of which we owe to the inventive genius of Sir William Bowman, ought to be extremely slender, with a cutting edge of not more than a millimetre in extent. Its shaft should so completely fill the wound made by its point as to prevent the escape of the aqueous humor by its side during the operation. This would cause the lens to fall forward against the cornea, and embarrass the use of the needle. Lower down the instrument is furnished with a shoulder, which renders its penetration into the eye, beyond a certain depth, impossible.

Fig. 572.—Discission Needle.

The patient may sit in a chair, facing the operator, unless anæsthesia be employed, when the recumbent position is of course preferable. The objections to the use of anæsthetics during the extraction of cataract do not apply to the operation of discission. Although the pain is not excessive, the subjects are young and consequently nervous; and, as will be seen, it is important that sudden spasmodic attempts to close the eye should not be made. Narcosis is therefore generally desirable, and its practice renders an assistant, for the most part, unnecessary. The pupil, as has already been stated, should be fully under the influence of atropine. The lids being separated by the introduction of the speculum, the eye is grasped by the fixation forceps at a point opposite to that selected for the introduction of the needle, generally over the insertion of the internal rectus. The point of the needle is now applied to the cornea midway between its centre and periphery, downward and outward, and made to transfix it in the direction of the posterior pole of the lens, and perpendicular to the corneal surface, so as not to penetrate it obliquely. As soon as the needle has passed in up to its neck the handle is lowered and the point carried forward until it touches the anterior capsule at a point outward from its centre, perhaps midway between that and its periphery. Raising the handle, and now regarding the instrument as a lever, the fulcrum of which is where it passes through the cornea, the operator makes its point descend along the face of the capsule, and inflicts on this membrane a vertical wound, some two millimetres in extent. Lowering the handle now, and at the same time slightly withdrawing the needle, so that its point is no longer in contact with the capsule, he again pushes it forward, directing this time to a point on the nasal side of the horizontal meridian of the capsule, midway between its centre and periphery, and then making it inflict on its face a horizontal wound, precisely similar to the vertical one already made. The needle is then gently and steadily withdrawn, being held in the same position as when it entered the eye. At the instant of withdrawal it is well for the operator, if unassisted, to release the fixation

forceps and raise the speculum slightly from off the eye, with his left hand, so that no pressure may be made upon it. The aqueous humor is thus less likely to escape, and the pupil consequently remains dilated. For a similar reason the removal of the speculum must be conducted with great care, and without touching the eyeball. If anæsthesia remain profound no spasmodic closure of the lids will occur at this juncture, and no aqueous be lost.

Great care must be taken not to bruise or crush the cornea, by too forcible manipulation of the needle, and to this end it should be simply allowed to lightly rest on the cornea, at its point of passage through it. The incisions should be as nearly as possible at right angles with each other, and should not be extended as far as the equator of the lens, in order to avoid too rapid swelling, as well as adherences between capsule and iris (Arlt). Should the needle slip out of the eye before the operation is completed it may be reintroduced, unless the aqueous has escaped, in which latter case the operation must be desisted from until the aqueous has again collected.

When a single operation proves sufficient the average time necessary for the absorption of the lens is ten weeks. But the process does not always go on uninterruptedly. A small capsular opening may be so blocked by the protruding fragment of lens as to cut off the access of aqueous humor to the parts behind, and absorption of this fragment may be followed by closure of the wound. In such cases the operation must be repeated, and larger incisions made. Occasional paracentesis of the anterior chamber greatly promotes absorption, but would be needed only in exceptional cases.

After-treatment.—A bandage is of doubtful utility. With very young children it encourages weeping, and its moral effect is at any age depressing. A shade, covering both eyes, may be given, and the room be dimly lighted. The pupil must be kept permanently dilated with atropine, a half per cent. solution of which should be applied three or four times a day, except in the case of very young children, in whom there is danger that symptoms of intoxication may manifest themselves. The atropine is to be continued as long as the absorption is going on, though after the first it need not be applied so frequently. If symptoms of reaction occur, as indicated by watering, undue ciliary redness, and local pain, strict quiet is to be enjoined and cold compresses applied to the eye. If they continue, one or more leeches may be applied on the temple, care being used to apply the leeches as far as possible from the eye itself. The bowels are to be kept open. If no relief is experienced, and the symptoms grow more pronounced; if tension increase, chemosis appear, and pain become more severe, it will probably be necessary to open the anterior chamber and evacuate the aqueous humor through an opening sufficiently large to allow any detached fragments of lens substance to escape at the same time. In extreme cases it may be necessary to practise linear extraction of the whole lens, with or without iridectomy.

Modified Discission.—In cases in which the pupil fails to respond promptly or thoroughly to atropine, or in which other indications of a tendency to inflammation are present, the operation of discission is rendered much more likely to succeed by the performance of an iridectomy three or four weeks before the use of the needle is undertaken. The excision of iris should be done upward, and the piece removed be of good size, and extend up to the ciliary edge of this membrane. The increased area thus given to the pupil lessens the number of points of contact between the cortical substance and the iris, renders contraction of the pupil much less to be dreaded, and diminishes the danger of secondary glaucoma. This last complication is not infrequently the cause of the blindness that sometimes follows discission, and the likelihood of its occurrence varies directly with the advance in age of the individual. In the performance of this modified discission Wecker[5] advises that the capsule be opened principally within the area of the new pupil, thus limiting the precipitation of fragments of the crystalline into the anterior chamber, and regulating the advance of the absorption. When the upper portion of the lens has thus been removed, its lower part may more advantageously be attacked.

With regard to the operation of discission in general, it may safely be stated that, allowing the cases to be properly selected, and due care used in its performance, it is the safest and surest method at our command. Total loss of the eye is, under these circumstances, excessively rare.

In former times yet another method was practised, having for its object the removal of the cataract from the axis of vision, without taking it out of the eye, namely, the operation of *reclination* or depression. A needle, specially adapted to the purpose, was passed in through the sclerotic, and used to tear the opaque lens away from its attachments, and lay it at the bottom of the eye. False in principle, and often disastrous in result, leading to restoration of vision in but from fifty to sixty per cent. of the cases in which it was used, this operation has justly been abandoned, and is, therefore, no longer to be described among the methods in use at the present day. It is still, however, of interest in a historical point of view, and will be alluded to at length in a subsequent portion of this article. For the present we proceed to the consideration of those operations which rest on the principle of the total removal of the cataract from the eye, and commence with the one involving the smallest solution of continuity, the method of

Suction.—This may be considered the operation of aspiration applied to cataract. Throughout the series of operations that have for their object the extraction of the lens, one of the great dangers to be apprehended is that connected with the healing of the wound necessarily inflicted on the eye. The larger this is, the greater the danger of inflammatory and other complications. Such accidents are least to be dreaded after a discission, they are appreciable with a linear extraction, and, as will be seen, the risk becomes greatest of all in the case of flap extraction. A method which should bodily and entirely remove the cataract through the smallest possible opening, avoids at once the dangers attendant on slow absorption, and the chance of the imperfect healing of a large wound. The operation of suction fulfils both these conditions. It is accomplished by means of an instrument formed from the glass barrel of an ordinary subcutaneous injection syringe, to one extremity of which is attached a piece of rubber tubing ending in a mouth-piece, while on the other end is a bent hollow needle of large size, open at its extremity. This needle is passed through a small opening in the cornea and anterior capsule, the air in the tube is then exhausted, and the soft cataract substance flows in to take its place.

This, in brief, is extraction by suction. It is a method of great antiquity. Evidence exists of its having been used in the East in the fourth century, and frequent subsequent references are made to it in ophthalmic literature. In 1846 it was revived by Laugier, who made his opening in the sclera, and introduced the point of the suction-needle through the posterior capsule. Teale, in 1864, published a drawing of an improved instrument, and recommended a method of operating which is substantially that in use at the present day. Since then most authors refer to the proceeding. Yet it cannot be said to have ever yet found its way into general favor, or to have met with the appreciation which, in a certain class of cases, it really deserves.

It is probable that extraction by suction would have attained greater popularity had the indications for its performance been better understood, and the class of cases to which alone it was applicable, more sharply defined. Authors, for example, report instances of subsequent inflammation and failure in lamellar cataract, a form to which this operation is wholly inapplicable. It should never be employed save in cases of known soft or liquid cataract, and in the traumatic form of the disease occurring in persons under the age of thirty. And in the latter class some time should be allowed to intervene between the accident and the operation, several days, or even a week, being, if possible, suffered to elapse, in order that the whole of the lens substance may become thoroughly

opaque. The instruments needed are a spring speculum, fixation forceps, bent broad needle, and the suction apparatus (Fig. 573). To the form of this latter especial attention is directed, as the figure here given differs materially from the instrument described by Mr. Teale, and generally used abroad. Our barrel is shorter, and slightly less in diameter than the English; the neck of the hollow needle, at its lower end, exactly fits the opening made by the broad needle, and the opening is across the extremity (Fig. 574) instead of being on its front face. The rubber tube that connects with the mouth-piece has a coil of light wire running the entire length of its interior. Each of these modifications offers a corresponding advantage, as will be seen when the operation comes to be described; and the greater favor it has met with in America may with justice be attributed, at least in part, to the superiority of the native instrument.*

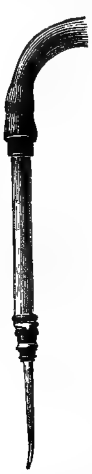

Fig. 573.—Suction Apparatus. (Reduced in size.)

Operation.—This is by no means devoid of pain, and an anæsthetic may be used to advantage. The pupil should of course be fully dilated. The surgeon, sitting behind the patient's head, fixes the eye with forceps, and makes, with a bent broad needle, an oblique incision through the cornea at a point outward from its centre and about three-fifths of the distance between that and the sclero-corneal junction; preferably in the outer-upper quadrant on the right side, in the upper-inner on the left. The point of the needle is carried across the anterior chamber, made to penetrate the anterior capsule, and then withdrawn. If this be carefully done, all the aqueous humor may be retained. The suction instrument is now introduced, its orifice being directed upward, and its point brought in contact with the lens substance. This being done, the air is withdrawn by the mouth, the force applied being perhaps similar to that used in smoking a well-made cigar. The neck of the hollow needle exactly fitting the wound, the instrument may be rotated, advanced and in part withdrawn, without loss of aqueous; and the important advantage is thus gained of not coming in contact with and bruising the iris. After the lens matter has filled the instrument it may be withdrawn, cleansed, and if necessary again inserted, though it will be better if this can be avoided. While the suction is going on the wire in the flexible tube prevents this from doubling on itself, and thus obstructing the draught of air. The shape of the aperture of the needle enables the surgeon to search for separate portions of lens matter, and apply the point directly to them, while they are drawn in with a much greater facility than would be the case with an opening differently situated. The operation completed, the instrument is withdrawn and a bandage applied. It is ordinarily unnecessary to keep the patient in bed more than twenty-four hours, or even to retain a bandage for a longer period. A shade may be worn over both eyes, until all redness has disappeared, but the amount of reaction is often astonishingly slight. A fear has been expressed lest vitreous should be drawn into the tube. This seldom happens, especially with the instrument here described, the length having been curtailed and the calibre reduced in order to get less atmospheric pressure and thus avoid the accident.

Fig. 574.—Magnified Picture of Point of Suction Instrument.

As regards the results of the suction operation, the reports of the Massachusetts Charitable Eye and Ear Infirmary for the last eleven years show the performance of one hundred and seven operations by suction. In some of the reports the results of that year are given, in others the number of operations is simply stated; no selection in either case having been made. In the 65 recorded cases the results are as follows: full success, 46; partial, 18; loss, 1. In five of these cases vision was perfect, that is ten-tenths.

Simple Linear Extraction.—In the operation just described the opaque lens substance was removed through a minute opening, by being made to flow into a vacuum. In that now under consideration the same thing is effected through a larger opening and by pressure. It is used for the same class of cases, viz., liquid, soft, and traumatic cataracts, in those who have not yet passed the age of twenty-five; and is moreover applicable to shrunken or rudimentary cataracts, on which suction would have no effect. And it is to be borne in mind that, while extraction by suction has never yet found universal favor, or been much practised out of England and America, linear extraction has long and generally been regarded as an operation both justifiable and valuable.

Fig. 575.—Straight Lance Knife.

The instruments used in its performance are a spring speculum, fixation forceps, straight lance knife, cystitome, and Daviel spoon (Figs. 575, 576, 577). Iris forceps and fine scissors should be in readiness, in case it is found necessary to excise a prolapse. The forceps may also have to be used where a shrunken cataract is to be removed.

The patient is to be in a recumbent position, and to have the pupil fully dilated. Anæsthesia, either general or local, may advantageously be employed. Having grasped, with the fixation forceps, a fold of conjunctiva to the inside of the cornea, the operator makes an incision with the lance knife in the corneal substance, perpendicular to the surface of this membrane, and at a point on its horizontal meridian either midway between its centre and outer edge or, if nearer the latter, at least two millimetres removed from it. As soon as the point of the instrument has entered the anterior chamber its direction is changed, and the knife is pushed forward in a plane parallel to that of the iris. A wound of from six to eight millimetres having been made, the lance knife is slowly and steadily withdrawn, care being taken to keep it always in the same plane, and thus avoid the too rapid escape of the aqueous, an event which would be followed by the contraction of the pupil. Owing to the triangular shape of the knife it is evident that the inner wound must be smaller than the outer, and it is well to attempt to equalize the two by directing the point of the lance either a little upward or a little downward, as it is withdrawn. But it should never be rotated, and should exert as little pressure as possible.

Fig. 576.—Cystitome.

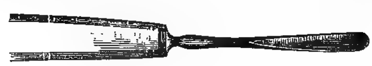

Fig. 577.—Daviel Spoon.

If the capsule is opaque, or if we are seeking to extract a shrunken cataract, a small sharp hook, or the iris-forceps, may now be introduced through the wound, and the capsule or cataract seized and withdrawn. If, however, we are dealing with an ordinary soft cataract, the next step is the opening of the capsule. The cystitome is passed through the wound, by gently pressing it against the outer edge, its cutting edge being held parallel with the face of the cornea. Once in the anterior chamber its flat is made to glide over the front of the cataract, until the point at which it is desired to commence the capsular opening is reached. The handle of the instrument is then

* This instrument is the one in use at the Massachusetts Charitable Eye and Ear Infirmary, and the modifications here detailed are largely due to Dr. Robert Willard.

turned so as to have the edge face the capsule, on which a wound is inflicted by the withdrawal of the cystitome in its new position, care being taken that the handle is again rotated just before the edge of the pupil is reached, so as to avoid wounding the iris. If the cataract be very soft the cortical mass will now begin to escape, and rapidly fill the anterior chamber. Many operators content themselves with this single opening, which is quite sufficient when a Graefe's cystitome is used, as a triangular flap is thus torn from the capsule. (This is the instrument given in Fig. 579.) If a straight cut be made in the capsule it must be supplemented by another running at a slightly different angle; a large capsular opening being essential to the entire removal of the cataract, as well as the prevention of secondary capsular opacity. Many of the cataracts removed by this operation are very thin, and care must be used not to sink the point of the cystitome so deeply in the mass as to wound the posterior capsule.

The opaque lens is next to be removed by pressure. At this stage of the operation it is better to take out the spring speculum, and to raise the upper lid with the thumb of the left hand. The rounded back of the Daviel spoon is now to be applied to the portion of the cornea that remains between the opening and the periphery of this membrane, and the wound so made to slightly gape. Pressure thus judiciously applied, aided by a slight amount of rubbing in the same region, will often cause the expulsion of the lens substance. But if this takes place but slowly, or ceases altogether, counter-pressure may be applied through the upper lid, at the opposite side of the cornea, by means of the thumb that is used to hold the lid in place. The pressure and counter-pressure thus made must be used alternately, with a gentle rocking motion, until the last portion of the cataract has emerged and the pupil has taken on a uniformly black appearance.

If the nucleus should turn out larger or more consistent than was expected, and hence refuse to pass through the wound, the Daviel spoon may be gently introduced and an attempt made to extract it, either whole or piecemeal. Care must be taken not to rupture the posterior capsule, as the escape of vitreous both complicates and retards convalescence, besides at once interrupting the operation if it occurs in its early stages. The fragments of the cataract are then often driven apart and away from the wound, and cannot in many cases be collected or removed without entailing a dangerous loss of the vitreous humor. If a prolapse of the iris takes place, it may be allowed to remain until the cataract has been removed, when it will often return spontaneously, or can be made to do so by gentle rubbing through the closed lids. But if it obstinately retains its position, it must be at once excised. The healing of this into the wound might not only alter the corneal curve, but prove a source of irritation by the traction it would exert, thus giving rise to serious trouble. It might also increase the density of the scar. The more peripheric the wound the greater the danger of prolapse.

Fragments of the cataract remaining in the pupil imbibe aqueous humor, swell, and may thus give rise to grave inflammatory symptoms; causing iritis, and delaying or preventing the healing of the wound. It may not be always possible to effect a complete removal of these portions, owing to the size of the wound, the consistency of the cataract, or the lodgement of the smaller pieces in remote situations, inaccessible to ordinary pressure. As Arlt, whose account of the operation has largely here been followed,[9] justly observes, simple linear extraction is by no means as universally applicable in cases of soft cataract as the first accounts of the operation, given by Graefe, would lead one to suppose.

After-treatment.—After having instilled a drop of a solution of atropine, and ascertained that the lips of the wound are in proper coaptation, as well as that no remains of the cataract or coagulated blood are to be found in the conjunctival sac, the eye is closed, and a simple compressive bandage applied over each eye, thus securing absolute repose. An elliptical piece of linen is first laid on each eye; on this are placed little tufts of fine charpie, flattened into small disks; and each orbital hollow is gradually built up with these, laid the one on the other, and as evenly distributed as possible. The hand, passed over the summit of the heap, should not distinguish the prominence of the eyeball. This process having been completed, the whole mass should be made to exert gentle pressure on the eye by means of a bandage, which may be either a simple cotton or flannel roller, or, still better, the so-called Liebreich bandage. The simplest form of this well-known appliance is a cotton band, about thirty centimetres long and six wide, knit in small alternate squares, the threads in adjacent squares running at right angles to each other. Long tapes are attached to each of the four corners. The peculiar construction of this band ensures a considerable degree of elasticity, and it is held in place over the eyes by securing the tapes behind the head, the two upper being tied above, the two lower below the crown. It is well to remove the bandage some eight hours after the operation, gently sponge the outer surface of the lids, and apply a fresh dressing. If no pain, swelling, or excessive lachrymation be present, nothing will be gained by opening and examining the eye. At the end of twenty-four hours, during which time the patient has been kept in a recumbent position, it will be well to open the eye and instil a drop of a solution of atropine. The bandage is now to be changed once a day for three or four days, when it may be removed altogether and a shade over both eyes substituted. After the first day the patient may leave his bed. As the redness slowly disappears, more light may be admitted, and moderate use of the eyes allowed. It must be remembered that the wound requires several days to consolidate, and that during this time it is no difficult thing to separate its edges.

Local pain, redness, and increasing photophobia are evidences of excessive reaction. The bandage may then be removed and cold compresses substituted, leeches applied to the temple, and even subcutaneous injections of morphine made in the same region if the suffering is considerable. The bowels must be kept open. If none of these measures give relief, the aqueous humor is to be evacuated; better, according to Arlt, through a peripheric puncture, than by reopening the original wound. In spite of all these precautions, irido-cyclitis may ensue, and even give rise to sympathetic affection of the remaining eye. Such cases are, happily, very infrequent.

We now come to the consideration of one of the most important operations on the eye—that for the removal of senile cataract. It is proper to consider it immediately after linear extraction, just described, inasmuch as the most approved method now in use is that of peripheric linear extraction; a proceeding somewhat allied to the foregoing, and the general adoption of which has resulted in the virtual abandonment of flap extraction, so universally practised less than a generation ago. Before, however, commencing the discussion of this method, it is desirable to consider one or two plans that have been recently proposed for the artificial ripening of senile cataracts, the formation of which proceeds with unusual slowness. This delay in the growth of cataract has been alluded to in an earlier portion of this article. In many cases, as was there stated, it proves a serious misfortune to the patient. All power of using either eye on near objects may be gone; it may even be difficult for the individual to move about unattended, especially in strange places, and he may thus become a burden to his family. Meanwhile the cortical substance still retains a portion of its transparency. The best years of life are passing away, or those dependent on the patient may be reduced to poverty in consequence of his inability to continue their support. Something ought, under such circumstances, to be done; and the alternative to removing an unripe cataract is the artificial production of maturity.

Two methods alone are regarded at the present day as offering ordinary chances of safety. The first is that proposed by Professor Förster, of Breslau, in 1881, and consists in the performance of an iridectomy upward, together with the rubbing of the cornea, over the face of the lens, with the angle of a strabismus-hook. There being no anterior chamber, the pressure is directly applied to the lens through the intervening cornea. "The effect in ripening the cataract," says Förster, "is frequently to in-

terrupt the entire reflex from the fundus within six days. In from six to eight weeks at farthest the cataract entirely matures." At the time of his bringing out this method he had practised it some five years and in about one hundred and fifty cases. He considered it chiefly applicable in cases of senile cataract with hard nucleus, and partially opaque cortical; but advised that it be not employed in posterior polar cataract. He warned against using a pressure, on the one hand, so light as not to hasten the cortical opacity, and on the other so extreme as to rupture the zonula. Recently Dr. Charles Bull, of New York, has given an analysis of thirty cases, in which he employed this method. In addition to the rupture of the zonula, which may be produced by too strong pressure, he alludes to another consequence, "a striated or radiating opacity of the cornea, which seems to be confined to the anterior layers, frequently remains for a long period, and fades out but slowly." He also recommends a rotatory rubbing or massage. Slight iritis has been observed to follow the operation by several observers, including the present writer. In Dr. Bull's series, iritis occurred five times. All his cases were successful, vision ranging between $\frac{20}{40}$ and $\frac{20}{100}$ in all but three, in which it was under $\frac{20}{100}$. The average duration of the confinement, after the first operation, was five days.

The second method of artificially ripening a cataract was alluded to by Förster when he brought forward the operation above described. It had been, he said, observed by Snellen that a simple iridectomy would sometimes hasten the progress of lenticular opacity. This he confirmed from his own experience. In a recent publication Jakobson again calls attention to this fact. "It is well known," he says, "that, up to within a short time, people half blind were obliged for months, and sometimes even for years, to rely on extraneous aid. By the performance of an iridectomy we are now enabled to offer them a prospect of sight within three months." [10] He goes on to say that his experience with Förster's operation has been unfortunate, iritis and inflammatory thickening of the anterior capsule having occurred in his practice. An iridectomy alone, in cases of unripe cataract, has been followed by inflammatory reaction, yielding, however, readily to atropine and fomentations.

Of these two methods the second is undeniably safer, as offering less instrumental interference with the eye. It possesses the advantage of being, in itself, one of the steps in peripheric linear extraction, and its anterior performance leaves just so much less to be done when the cataract is finally removed. The practical objection to it is the fact that it subjects the patient to two operations on the eye, instead of one; two confinements with both eyes bandaged in a darkened chamber. The effect of all this on the general health and morale of the individual will vary in different cases; and therefore renders it impossible to lay down any fixed rule with regard to the propriety of producing artificial maturity. All that can be said is, that in ordinary cases of slow growth, the performance of the additional operation would seem a lesser evil than weary months of waiting for natural ripening.

A few general remarks with regard to the extraction of senile cataract may fitly precede the descriptions of the various operations devised for this purpose. And first with regard to the induction of anæsthesia. On this point there has been much difference of opinion, its use having been comparatively general in this country, but far less frequent on the Continent of Europe. The experience of the present writer has convinced him that the state of anæsthesia throws appreciable obstacles in the way of a successful extraction, and that its regular employment tends to diminish the number of favorable results that would otherwise be obtained. This opinion is based on several grounds. The necessity of fasting before the administration of the ether or chloroform, and the inability to retain nourishment for some time afterward, have a depressing effect, especially on the aged and feeble. The amount of congestion induced in many by the inhalation of ether, encourages hæmorrhage and embarrasses the performance of the operation. The patient's ability to move his eye at will being lost during anæsthesia, every needed motion has to be given to the eye by traction with the fixation forceps, inflicting a fresh bruise at every application, and sometimes leading to a loss of vitreous. The collapse due to anæsthesia annuls tension and renders the removal of cortical fragments proportionally difficult. After the operation the patient is incapable of giving information with regard to the clearness of his acquired sight, and moreover loses the moral support of having once seen, a support well calculated to cheer the succeeding dark days of convalescence. The surgeon, too, is thus deprived of important knowledge with regard to the result of the efforts he has made to clear the pupil. Finally, the nausea that so often comes on as the effect of the ether passes off, the retching and vomiting, that sometimes endure for hours, can only have an injurious effect on an eye so recently laid open, besides rendering the patient unable to take nourishment and depressing his morale. To ascertain whether these objections were more than theoretical, two series of cases were operated on, a certain number with and an equal number without ether. Each series consisted of one hundred, and the great difference in the percentage of success was wholly in favor of the non-administration of the anæsthetic.

This discussion, however, becomes less important in the face of a discovery published while this article is in the course of preparation. Cocainum muriaticum, a preparation made from the alkaloid of Erythroxylon coca, dissolved in distilled water in a four per cent. strength (0.2 to aq. dest., 5.0), and dropped into the conjunctival sac, produces local anæsthesia within five minutes, especially if twice applied during this time. The observation was originally made by Koller, in Vienna, and demonstrated by Brettauer at the Heidelberg Congress, September 14, 1884. This renders the production of general insensibility no longer necessary in operations for cataract. Generally three minutes after the second application the eye loses all sensitiveness. If the application of the fixation-forceps is felt, however, a third application is quickly followed by entire anæsthesia. After the corneal cut has been completed, and before proceeding to the excision of the iris, it is well to make a fresh instillation of the solution; and even to slightly depress the upper lip of the wound, in order that a little may enter the anterior chamber, and ensure anæsthesia of the iris. Should the operation prove a protracted one, the applications should be renewed at intervals of a few minutes until its conclusion.

A very important question next arises, as to whether the eye shall be prepared for the removal of the cataract by the dilatation of the pupil, as was formerly the usual custom. This practice was generally continued after the operation of flap extraction had given way to that introduced by Graefe. The arguments for the instillation of atropine before extraction were, in brief, that there would be more room for the knife, in its passage across the anterior chamber; that its point would be less likely to catch in the iris, and a wound or dialysis would consequently more seldom follow; and that the secondary dilatation that ensues on the re-establishment of the anterior chamber, would tend to keep the edge of the iris clear of any fragments of cortical substance that might remain behind, and lessen the likelihood of a closed pupil and of a secondary cataract. It began, however, by degrees to be found that, where mydriasis had not been induced, it was easier to replace the iris after extraction, and thus prevent its healing into the corners of the wound. To prevent this accident it was even advised to apply a solution of eserine, after the lens was removed.[11] Acting on this hint, the present writer has been in the habit of applying the eserine an hour before the operation. At the time of its performance there is then found a considerable contraction of the pupil, which does not in the least interfere with extraction, and which yields when the anterior chamber is re-established. It then exerts on the iris a degree of traction that reduces to a minimum the danger of its healing into the corners of the wound, and would even seem to render this complication less frequent than formerly. This contraction of the pupil readily yields to atropine, should it be found necessary to employ it dur-

ing the after-treatment. Eserin. salicylat. rubbed up with vaseline in the strength of one per cent., will be found a convenient preparation to use, on account of its being less affected by time than the ordinary solution. The application of eserine is sometimes followed by slight temporary pain, and is hence contra-indicated at the time of the operation. Its use has been objected to on the ground that the tendency to a loss of vitreous might be increased, but this theory has been proved unfounded.

The advantages of operating on senile cataract in an establishment especially arranged for the purpose, have already been alluded to. Should this course be adopted, it is well to have the patient occupy his room the night before the operation is performed. A certain amount of acquaintance with the bed, the surroundings, and the attendants is thus acquired before the bandage that prevents all use of the eyes for several days, has been finally applied. Another advantage is that there may often be met, in the same place, some convalescent who has already passed through the operation, and who can be brought in contact with the intending patient. A few words of encouragement from such an individual will often do more to dispel apprehension and establish confidence than anything coming from the surgeon himself.

If a trained and experienced nurse be present, the services of a professional assistant may readily be dispensed with. The patient awaits the surgeon in bed and undressed. As the bandage to be applied after the operation is monocular, the eye that is not to be touched is closed by several short strips of isinglass-plaster, crossing each other. A short preliminary drill in turning the eye in any given direction, without any corresponding movement of the head, will be found of much use; the patient being directed to roll the eye up, down, or to either side at the request of the operator; being also cautioned, the while, to avoid straining, and to breathe easily and naturally. In the case of very deaf people it is well to arrange a little code of signals in advance, a tap on the forehead being understood to mean a direction to look up, one on the chin to look down. Under ordinary circumstances the duty of the nurse is confined to handing the iced sponges as they are needed, and supporting the head while the bandage is being applied.

FIG. 578. Graefe Knife.

FIG. 579. Cystitome.

FIG. 580. Rubber Spoon.

FIG. 581. Rubber Spatula.

PERIPHERIC LINEAR EXTRACTION.—This is commonly known as the method of Graefe. The instruments needed are a spring-speculum, fixation-forceps, elevator, Graefe extraction knife (Fig. 578), cystitome and rubber spoon (Figs. 579 and 580), Daviel spoon, iris-forceps and scissors, and a small, straight, flexible rubber spatula (Fig. 581). A few bits of soft sponge, floating in ice-water, are also required, as well as charpie, bandages, etc.

The surgeon stands at the head of the bed, and should be able to operate on the right eye with the right hand, on the left with the left. Local anæsthesia having been fully brought about, he introduces the spring-speculum and locks it in place, being careful not to stretch the lids to a distressing extent. Requesting the patient to look up, he firmly grasps the eye with the fixation-forceps, a little below the cornea. Holding the knife with its edge up, he now proceeds to make the cut. The accomplishment of this is not without its difficulties, and demands a careful description. It can best be understood by reference to the following diagram (Fig. 582), taken from Arlt.[12] The knife is entered, with its blade up, at the point *a*, one and one-half millimetres from the corneal edge, and two millimetres below a tangent to the upper corneal periphery on the temporal side, and directed at first toward the point *b*, situated downward and inward from the pupil. Having been carried steadily forward some six to eight millimetres in the direction of this point, the handle is lowered, the point of the knife directed to that of counter-puncture *c*, pushed forward, and made to emerge at this place. The wound to be inflicted will thus be some twelve millimetres in length. It is better now to remove the fixation forceps, thus avoiding the danger of undue pressure, and to request the patient to look down. The wound is completed by a sawing movement of the knife, alternately advancing and withdrawing it a little, directing its cutting edge toward the point at, or just behind, the upper corneal edge, where it is intended that it should emerge (Fig. 583). No attempt should be made to divide the conjunctiva until the scleral cut is complete. The blade of the knife may then still be directed upward, but a little outward, and a conjunctival flap formed some two or three millimetres in height. Raising the handle of the knife abruptly, from the temple, is advised by Arlt as facilitating this. It will be seen that this is not strictly a linear wound, as originally intended by Graefe, so that the title of the operation is, to some extent, a misnomer. But the conjunctival flap can only be formed when the cut is made as above described, and the advantages of this flap as a protection to the scleral wound are at once evident. A curved cut is, moreover, longer than a linear one. The external cut being twelve millimetres in length, the inner one would measure from nine to ten millimetres, and as the diameter of the lens rarel exceeds nine millimetres, there is sufficient room for its emergence.

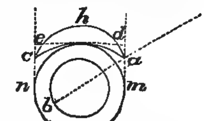

FIG. 582.—Ideal Peripheric Linear Cut. (Corneal diameter 12 mm.) *am*, *cn*, tangents to the horizontal diameter *m n*; *de*, tangent to the vertical diameter; *a*, point of puncture; *a*, *b*, line of direction of back of knife at time of puncture; *c*, point of counter-puncture; *a*, *d*, *h*, *e*, *c*, course of conjunctival wound; *a*, *c*, course of cornea-scleral wound on outer surface of sclera.

Should there be considerable hæmorrhage from the conjunctival flap or the scleral wound, filling the anterior chamber and obscuring the view of the iris, it is better to temporarily remove the speculum and hold soft iced sponges in gentle contact with the closed lids. In a few minutes the bleeding will cease, the eye can be again opened, the speculum reinserted, and the coagulated blood removed with iris forceps. Ordinarily, however, we proceed directly to the second step in the operation, the iridectomy.

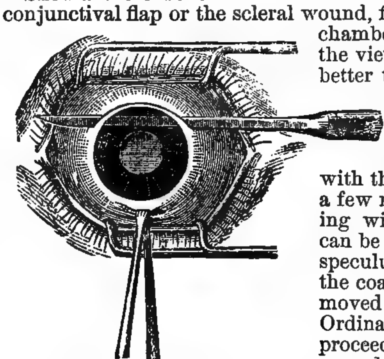

FIG. 583.—(From Michel's *Lehrbuch.*)

It is better to accomplish this without resuming fixation. The iris scissors are taken in the right hand, the forceps in the left. The patient being directed to look down, the conjunctival flap is lifted with the forceps and laid backward over the cornea. The iris is now seized at its pupillary edge, the forceps being well carried over toward the end of the wound at the operator's right, withdrawn, lifted forward, and a straight cut, or rather split, made in its tissue from the pupillary to the ciliary edge; it is then drawn over toward the opposite corner of the wound, being divided as it is thus drawn by repeated strokes of the scissors, and the piece finally completely excised by passing the scissors on the other side of the forceps and repeating the first cut from the pupillary edge

backward. A coloboma of from four to eight millimetres in extent is thus formed. Professor Arlt, whose method of executing the iridectomy is here closely followed, advises strongly against tearing the iris from its ciliary attachment, rather than cutting it as just described. By following the latter course hæmorrhage is far less likely to occur. The edges of the coloboma are to converge toward the pupil, and if considerable iris tissue is left in the corners of the wound it is to be separately excised. At this stage it is often advised to replace small prolapses of iris at the wound angles with the rubber spatula; but as the delivery of the lens is almost certain to be followed by their recurrence, it is better to wait until this has taken place and the pupil been cleared. Hæmorrhage may now, if at all embarrassing, be controlled in the manner formerly described.

Opening of the Capsule.—Careful watch should be kept over the amount of pressure which the spring speculum exerts on the eye. If this organ be unusually prominent, or the straining of the patient excessive, the speculum may be slightly lifted off by the unoccupied hand of the operator; or even removed altogether and an elevator substituted. Fixation, which has been dispensed with since the performance of the first step in the operation, is not again to be employed.

A word, in passing, on this subject. Sufficient stress has hardly ever been laid on the injurious effect on the eye of prolonged fixation. Each grasp of so delicate and sensitive a member with this rude instrument (toothed or serrated forceps), causes ciliary injection and acts as a local bruise, the multiplication of which may well tend to complicate or retard the healing process. Becker's remarks, in this connection, are most instructive. He says, "seizure of the conjunctiva bulbi, either alone or with the addition of the tendon of the rectus inferior, is ordinarily looked upon with indifference. And yet an appreciable injury is only too often thus inflicted. Though the fixation-forceps be used in the most careful manner, the point which they seize becomes for days the seat of a defined redness. If the teeth of the forceps are very sharp, the patient restless, and the conjunctiva fragile, as is often the case with the aged, bleeding follows, and the tissue may even tear." Speaking later of the wrenching given the cornea, ciliary body and iris, by drawing down the eye after the cut has been completed, he observes "the more or less perfect manner in which these secondary injuries are avoided goes very far to determine the varying success met with by operators of otherwise equal skill." [13]

The cystitome is introduced flatwise, at one corner of the wound, pushed forward until its extremity comes opposite the lower edge of the pupil, then turned with its cutting edge toward the face of the capsule, and drawn gently upward to the edge of the wound. To secure a free opening it is better to introduce it a second time, apply it at a point on one side of that first selected, and again draw it upward in a line diverging from the previous one. Care should be taken to exert little or no pressure backward, for fear of causing dislocation of the lens. If the eye be deep set it will be necessary to bend the stem of the instrument at an angle, some seven millimetres from its point. Should the anterior chamber be filled with blood that cannot be cleared away, the cystitome must still be used in the region of the supposed pupil; but it is well, under such circumstances, to somewhat restrict its excursions.

Arlt prefers, to the ordinary cystitome of Graefe, a sharp iris-hook with a flexible stem. In cases in which the capsule is opaque there is no doubt but that this membrane may be better seized with such an instrument, and brought to the edge of the wound, where it can be removed with scissors. The use of the hook demands, however, special dexterity on the part of the operator.

Delivery of the Lens.—We come now to one of the most critical portions of the operation, during which the escape of vitreous is most to be dreaded. Should this accident happen in the shape of a sudden gush, it is desirable to immediately close the eye. The withdrawal of the spring speculum takes time, as it has to be first unlocked and then carefully removed from under the two lids separately, and without tilting over the cartilage of the upper lid, a common occurrence. It has, therefore, long been the practice of the writer to remove the speculum, before proceeding to the delivery of the lens; and either to raise the upper lid with the forefinger of the left hand, or else to lift it by means of a simple elevator, which can be instantly slipped out if occasion demands. To effect the removal of the lens the patient is first directed to look down, and to keep his gaze fixed in this direction. Much difficulty is occasionally experienced in keeping this up, the eye exhibiting a tendency to roll upward. In such cases it may be found advantageous to place one of the patient's hands outside the bedclothes, and then request him to look persistently in its direction. It may serve to fix his attention if the nurse smartly taps the hand, from time to time. By getting the patient to look down we are able to exert pressure against the eye through the lower lid, and to thus escape the necessity of bringing any instrument in direct contact with the eyeball. The convexity of the Daviel spoon or the back of a large hard-rubber spoon is laid against the outside of the lower lid; pressed gently, at first backward and then upward, and then, if the lens shows a tendency to emerge and the edge presents itself at the wound, used to assist its expulsion by gently rubbing upward. Should the eye roll up, the pressure must, of course, be applied directly to the eyeball. The moment half the lens has passed through the wound, pressure is to be lessened, but not omitted, until the entire crystalline has emerged. If, in spite of judicious pressure, the lens fails to present itself at the wound; or, having presented itself, to advance, the first thing to do is to repeat the opening of the capsule, a delicate and often difficult proceeding.

The lens once removed, the lids may be suffered to close and the patient to rest a few moments. Sponges dipped in cold water may be applied to the eye externally, and frequently changed. When the eye is again opened, the pupil is to be carefully examined. If lens-fragments or coagula occupy its area, they may be expelled by repeating the manœuvre for the removal of the lens, rubbing upward while the patient looks down. They should, however, first be collected in the centre of the pupil by closing the eye and rubbing gently over its convexity, in a circular direction, with the point of the forefinger. If the cloudiness is evidently due to opaque capsule, it is better to leave it alone, and trust for its removal to a secondary operation. Incising it with a cystitome or sharp hook, as is sometimes advised, would lead to an escape forward of vitreous, and might complicate recovery. When the pupil is apparently clear, vision must be tested. If the answers are unsatisfactory, if the patient cannot count or name the fingers held before him, his head of course being turned away from the light, the rubbing must be renewed. No inspection of the pupil by the surgeon gives information comparable to the actual exercise of vision by the patient himself; nor should the bandage be applied until the sight seems reasonably good. If, indeed, there were no other reason for this course, the advantage of the moral effect produced on the patient can scarcely be overrated.

The corners of the wound must now be carefully examined to see whether iris tissue has become incarcerated there. Should this be the case the flat rubber spatula may be used for its replacement, pushing it first out of the wound, and then gently patting or spreading it out in its proper position. The importance of thus clearing the wound, as well as the danger of allowing a prolapse of iris to heal into the cut, can scarcely be exaggerated. As soon as the anterior chamber has become re-established the influence of the eserine will again be asserted, and offer an additional safeguard against this accident. After the remains of the cataract and coagulated blood have been removed from about the wound and from the conjunctival sac, by means of the edge of a bit of soft linen or a similar fragment of sponge, the conjunctival flap is to be carefully lifted into place by the iris forceps and the eye closed; care being taken that the upper lid, in its descent, does not reverse the flap.

Accidents during the Operation.—The most dreaded is

the escape of vitreous. This may be due to a faulty position of the wound, to intraocular disease resulting in abnormal fluidity of this humor, or to the employment of undue pressure in expelling the cataract. While the moderate loss of vitreous may be simply followed by a lengthened and irritable convalescence, its escape in any considerable quantity is apt to entail retinal separation, choroidal disease, or even general inflammation of the eyeball. The accident is characterized by the appearance in the wound of a transparent viscid fluid. If it occurs immediately after the completion of the cut the iris is to be quickly excised. The removal of the lens has now to be effected, with as little further escape of the humor as possible. Any pressure would, of course, increase this tendency. No attempt is to be made to open the capsule, and the lens is to be removed by traction with an appropriate instrument. For this purpose the writer has always employed Critchett's scoop (Fig. 584), an instrument that combines lightness with flexibility, and effects reliable traction; occupying the while comparatively little space in the eye, and distending the edge of the pupil but slightly. Its employment demands a quick eye and a steady hand. If the eye is deep set the instrument is to be somewhat bent, and is then to be introduced with the patient looking down, and in such a direction that its edge slips behind the periphery of the lens. It is now quickly passed down until its lower rim is thought to be opposite the base of the lens, the handle is then to be sharply, but gently, inclined backward, and the instrument at the same time drawn up and out of the eye, bringing the lens with it. This manœuvre bears a distant resemblance to that by which a lever pries a stone out of the ground. A gush of vitreous generally occurs at the instant the lens emerges; the eye is, therefore, to be instantly closed and dressings applied. The lens is

FIG. 584.—Critchett's Scoop.

thus extracted in its capsule, and subsequent vision is apt to be unusually clear and distinct in cases in which a good recovery is made.

Where, after the operation, vitreous simply projects at the edge of the wound, separating its lips, some advise excision of the prolapsed portion with fine sharp scissors. It is better practice to leave it alone and trust to the influence of the pressure-bandage to effect its subsidence. Should this prolapse occur after the nucleus has passed out, but before the pupil has been thoroughly freed from cortical substance, the operator finds himself between the two horns of a dilemma. The lesser evil is to close the eye at once, and trust to time for the absorption of the remaining cortical. Bleeding into the anterior chamber may occur during either of the several stages of the operation, and has already been alluded to.

Bandage and After-treatment.—An elliptical patch of soft linen is to be laid on the eye, and the orbital hollow filled with small flattened wads of charpie, as was described in connection with the after-treatment of linear extraction. In the present case, however, one eye is already closed by strips of plaster, and the bandage is, therefore, to be monocular. Every surgeon has his favorite form; the writer prefers a flannel roller, 4.5 millimetres in width, and long enough to encircle the head three times alternately with a similar number of rising turns over the eye, one fold overlapping the other, the whole affording moderate compression and support. The bandage once applied the room is to be darkened, and the patient left in quiet for a few hours. He is to avoid turning over on the side of the operated eye. Should he desire to vary his position by lying on the opposite side, he is to lift his head slightly from the pillow, so as to avoid dragging on the bandage. Should the operation have been performed in the morning, the patient may be seen again in the course of the afternoon. At this, as well as subsequent visits, it is well to avoid letting in daylight, on account of the great change in illumination that may unexpectedly occur. The sudden emergence of the sun from behind a cloud may unexpectedly flood the room with light, and distress an eye used to entire darkness. A single candle is the best and most easily managed source of illumination. By the time of this visit the pad next the eye will generally be found more or less stiff and uncomfortable, having become soaked with blood and tears. It should, therefore, be changed. The outside of the lids may be gently bathed with a soft sponge, dipped in lukewarm water, but they are on no account to be separated unless something unusual has occurred. To this end the patient is to be cautioned, before the bandage is removed, not to open his eye, but to keep it softly closed. The feeling of soreness and the sensation of a foreign body between the lids will, by this time, have probably died away. The dressing having been renewed a bed-chair may be brought in, and the patient allowed to rest himself by sitting up in bed for a short time. Later in the evening a dose of chloral may be given. It is well to have a watcher in the room the first one or two nights.

At the visit on the following day, if the case be progressing favorably, the lids are again to be washed and the bandage renewed, but the eye is not to be opened. From this time forth the bandage may be changed once in twenty-four hours. By the third day the plaster, used to close the other eye, will ordinarily be found to have become quite stiff, and its edges will have rolled in, causing some discomfort. It is, therefore, to be soaked off. A Liebreich bandage may now be used over both eyes, instead of the flannel roller. By this time, too, the patient may sit up in an easy chair, and have his bed made. He is to spend an increasing portion of every day out of bed, until he occupies the latter only at night. The diet is to be nutritious, but all chewing should be strictly avoided. The room should still be kept darkened.

There is, among ophthalmic surgeons, a great diversity of opinion as to when the lids should first be separated and the eye examined. Arlt lays down no fixed rule, but intimates that this may occur at the second visit, twenty-four hours after the operation; and even sooner if necessary. The experience of the present writer has led him to adopt a different course. He gradually came to find that the eye did quite as well if the lids were allowed to remain closed two, or even three days. As time went on, a new fact forced itself repeatedly on his notice; that in certain cases, in which the healing process was interrupted by inflammatory complications, the first pain, lachrymation, or discharge followed accurately on the first separation of the lids, however carefully managed, and however hasty the examination. The case might have been doing perfectly well for three or four days; no swelling of the lids, lachrymation, or undue discharge being present, or the slightest pain experienced; the eye might then, for the first time, be opened and rapidly surveyed by a weak light, no lens being used and no trial of the vision made, and yet within a few hours pain would occur, and marked symptoms of inflammation be present. This happened so frequently that it became impossible not to connect the examination and the inflammation as cause and effect. Acting on this belief he kept prolonging the time that he allowed the eye to remain unopened, and now he rarely makes the first examination before the morning of the eighth day. At this time it is often remarkable to see how little evidence of the operation is present, a trifling redness in the immediate vicinity of the wound being sometimes all there is to be seen. This redness, slight at first, will be observed for several days steadily to increase before it begins to disappear.

The above course of treatment is applicable only to cases in which the healing process may be presumed to be progressing normally. The writer believes that the longer the examination is deferred, the more likely the patient is to do well, and he bases this opinion simply on experience. Of course, numerous theoretical objections to such a method might be alleged. It could be argued that the secretions of the wound, and the blood left in the conjunctival sac, being unable to escape, might decompose and act as sources of infection. This and other objec-

tions might be brought forward. To those urging them the writer simply suggests a fair trial of the plan itself, believing that they will, in the end, themselves find that the longer they leave the wound undisturbed, in contact with and guarded by the covering provided by nature, thus sealed and protected from any germs of contagion with which the atmosphere may be infected, and which the exposure of a single instant might attract, the more success they will meet with in the after-treatment of extraction.

One caution must here be given. While, as a rule, both eyes should remain covered until the eighth day, it must be borne in mind that some aged and weak people are peculiarly sensitive to the combined effects of darkness and solitude, and may be attacked by a form of delirium which renders them difficult to control. If this occurs the sound eye may be sooner uncovered, perhaps on the fourth or fifth day. After the removal of the bandage from both eyes, light may gradually be admitted into the room, the patient wearing a shade, or a pair of blue or smoked protective glasses, curved, to more effectually cover the eye, the so-called "coquille" spectacles. Several days should still be suffered to elapse before the patient is discharged from the immediate supervision of the surgeon. During this time the pupil is to be carefully watched, and atropine used if it evinces a tendency to contract, or if its area is at all occupied by remains of blood or cortical substance. Fifteen days after the performance of the operation the patient may ordinarily go to his own home, but he is to wear the protective glasses for a month or six weeks longer, and avoid exposure to bright light, or any use of the eyes. When two months have elapsed after the removal of the cataract he may cautiously commence the use of the appropriate glasses.

We have thus far considered a case of uncomplicated recovery, and must be prepared to deal with departures from this type, they being unfortunately not infrequent. Unusual duration of the pain connected with the operation itself may often be relieved by removing the bandage and sponging the outside of the eye with ice-water. If it still continues, the edges of the lids may be examined to see if any lashes have become inverted, and the under lid may be slightly drawn downward to allow the escape of any accumulation of tears. Cold compresses may be alternated with the compressive bandage, or even a morphine injection may be made in the temple. In extreme cases the linen pad next the eye may be thoroughly wet with atropine, although the use of a mydriatic should, if possible, be dispensed with for several days after the operation, on account of the danger of prolapse into the corners of the wound. If the pain continues, or even if, in the absence of pain, the lids swell and lachrymation or discharge be present, the eye must be opened and carefully examined by oblique light, the candle being held to one side and its rays concentrated on the eye by means of a convex lens of short focus. Iritis, if present, is to be treated by leeches to the temple, atropine, and the alternation of the bandage with warm, but not hot, fomentations. If there are signs of suppuration in the wound, the fomentations are to be even more regularly applied, twenty minutes at a time, every four hours, and the bandage is to be kept on in the interval, being applied even more tightly. The eye may, moreover, be bathed with the following antiseptic solution: Salicylate of sodium, 1 gram; boracic acid, 3 grams; dissolve in warm water, 100 grams; stir well, cool slowly, and strain.

Compresses, wet with this solution, may be constantly kept on the eye; if the inflammatory process continues and no benefit is derived from the fomentations and the bandage, quinine should be given in large doses, and the general health supported with generous diet and stimulants. The previous history and habits of every patient are to be well weighed by the surgeon; those addicted to the free use of stimulants would incur great danger of an unfavorable result if these were suddenly suppressed. Should any form of opium have been habitually indulged in, the customary ration must be allowed.

If thirty-six or forty-eight hours pass without accident it is probable that the eye will be saved, and some measure of sight retained. Iritis is still possible, but, if properly treated, is unlikely to result in blindness. One great danger to be guarded against during convalescence is a sudden blow on the eye, inflicted by the patient himself, during sleep or carelessly when awake. This may cause bleeding into the anterior chamber, or even rupture of the wound. The blood may be absorbed or the wound heal under a prolonged application of the bandage, and no ultimate ill effect be experienced; or a state of chronic irritation may follow, ending in closure of the pupil and necessitating the performance of a secondary operation. Or, at the worst, irido-cyclitis may ensue, the pupil closing and the iris being drawn forward until the anterior chamber is obliterated, all perception of light disappearing after weeks of suffering. There are even instances on record of this condition of things causing sympathetic irritation and ultimate loss of the remaining eye. It would be well, therefore, to proceed to enucleation in the case of an eye in this condition, especially if tenderness on pressure exists.

Secondary Operations.—After an ordinary extraction the anterior capsule retracts and leaves the area of the pupil occupied, substantially, by the posterior capsule only, thus exposing any portions of cortical substance that may remain behind to the full action of the aqueous humor. In cases, therefore, in which the cataract was not entirely mature, and in which lens substance as yet clear has escaped notice and been left behind after the operation, it may happen that a pupil which at first appeared clear and black is discovered, on removing the bandage, to be entirely blocked with opaque cortical masses, swollen and pressing forward. These may be absorbed quietly and vision be slowly gained. But they are more apt to give rise to inflammation of the iris, by the mechanical pressure which they exert upon it, and to cause this membrane to contract adhesions with them. After the inflammation subsides we may thus find a pupil contracted, drawn up, and filled with a dense membrane, a so-called secondary cataract. Another form of secondary cataract is the opacity of the capsule that sometimes occurs long after the extraction, and that does not appear to be connected with any unusual feature, either of the operation itself or of subsequent convalescence. Patients often return, years after the cataract has been removed, complaining that their vision, originally excellent, has gradually undergone diminution. The power of reading any but the largest type may perhaps have entirely disappeared. The capsular opacities in these cases are often apparently insignificant, hardly visible indeed by oblique illumination. But the ophthalmoscope shows the outline of the optic nerve to be indistinct and distorted; and the mirror alone, particularly that of the binocular instrument, plainly reveals a delicate web of opaque capsule stretched across the pupil, now distinct in one part and now in another, as the handle of the instrument is slightly rotated, and the direction of the reflected light thus changed.

To bring about a return of vision it is necessary to secure a permanent opening in this capsular screen. Numerous devices have been imagined for the accomplishment of this. Discission with a single needle is rarely sufficient. The introduction of a hook, through a small opening made for this purpose at the edge of the cornea, enables us to tear away a piece of the capsule, but may give rise to a dangerous amount of traction, and thus result in irritation or inflammation of the ciliary body. To avoid this, Bowman devised the so-called "double-needle operation." Two ordinary discission needles are used; one is taken in the left hand, is passed through the middle of the inner half of the cornea, and made to penetrate the thickened capsule; the other is held in the right hand, passed through a corresponding point in the middle of the outer half of the cornea, and introduced into the capsule by the side of the first. One needle is then held still while the other tears from it, or else each is made to tear the capsule in an opposite direction. In either case a *point d'appui* is gained, and the strain no longer comes on the ciliary body. Among other ingenious operations of this class is one devised by Dr. C. R. Agnew, of New York. Passing his first needle

through cornea and capsule, as in Bowman's operation, he makes an incision with a broad needle at the opposite corneal edge, being careful in withdrawing this needle to allow no escape of aqueous by its side. He then passes through the opening a sharp and flexible hook, engages its point in the capsule just where it is pierced by the stop-needle, and tears a hole from this needle which thus acts as a point of support.

Where the pupil is drawn up and filled with tough membrane, or remnants of lens substance enclosed in opaque capsule; where the iris, tightly stretched and thickened by inflammation, obstructs all access of light to the retina, the operations above described are impracticable. Simple iridectomy is rarely resorted to, owing to the difficulty experienced in grasping and withdrawing sufficient iris tissue. Iridotomy, incision of the iris itself, is here to be advised. Wecker's scissors, sometimes used for this purpose, are a pair of short and delicate blades, made to open and shut by the lateral movement of the two sides of the long forceps handle to which they are attached. A lance knife is first passed through cornea and iris, and the scissors are then introduced into the opening in the latter and used to give it increased length, one arm being inserted behind iris and thickened capsule, the other in front of them. If the wound thus made gapes, disclosing a clear black pupil, no further interference is necessary; if not, a second incision is made at an angle to the former one. The included flap may even be withdrawn with iris forceps and excised. Far simpler, and, in the writer's opinion, safer, is the incision of the iris and capsule by means of a narrow Graefe knife passed obliquely through cornea and iris, and made to act as a lever, incising the latter by simply raising or depressing its handle, according as its edge looks up or down, the cornea in this case acting as the fulcrum. By introducing the knife in a new place a second incision may be made at an angle to the former one. Vitreous is much less likely to be lost when iridotomy is done in this manner.

It is impossible, in an article like the present, to review all the different operations for the extraction of senile cataract that have been proposed, even within the present generation. That just described is the one in general use at the present day, and is considered to furnish, on the whole, a larger percentage of success than any other. There are, however, two methods that have attracted a good deal of attention and found influential advocates. They deserve at least a passing notice. Liebreich's method of extraction is performed as follows, the knife used being similar to that in peripheric linear extraction, only somewhat narrower: The patient is in the recumbent position, the pupil under the influence of atropine. Supposing the right eye to be the one to be operated on, the surgeon stands behind the head of the patient. He raises the upper lid with the forefinger, and steadies the eye by pressing lightly against the sclera with the middle finger of the left hand. The right hand holds the knife, whose back is directed horizontally and backward, while the plane of its blade forms an angle of about forty-five degrees with the horizontal meridian of the eye. The point is made to enter the sclera about one millimetre away from the edge of the cornea, and two millimetres below its horizontal diameter, and to emerge at a similar point on the opposite side. The knife is then made to cut its way out downward, forming a flap, the apex of which is two millimetres above the lowest point of the cornea. The cut itself is formed with the least possible sawing motion, the knife being in the first instance thrust so far forward that the section can be completed as it is withdrawn; and at the last moment the upper lid is suffered to fall. Next the capsule is carefully opened. "For the third act of the operation," says Liebreich, "we lay the Daviel spoon gently against the lower edge of the cornea; while the left forefinger, by which the upper lid is raised, exercises a slight pressure through the lid against the upper part of the cornea. The lens is thus slightly tilted, its lower edge presses against the posterior surface of the iris, folds it forward, glides over it to the edge of the pupil, overcomes the resistance of the sphincter, and engages itself in the wound, which contact with the Daviel spoon has already caused to open. The forefinger of the left hand slightly presses the upper lid from above downward over the cornea, and thus completes the expulsion of the lens. A similar manœuvre with the lid is again employed to extrude the cortical substance which has been left behind, after a little rubbing has been done to drive it from behind the iris toward the centre of the pupil. If, after this is completed, the pupil does not appear round, but seems drawn toward the wound, its natural shape may be restored by rubbing upward with the lower lid. If this does not prove effective the Daviel spoon may be introduced." [14]

This operation commends itself by its simplicity, by the small number of instruments which its execution requires, and by its comparatively slight interference with the eye. No extended statistics of its results are accessible. The dangers attending it are obvious—the possibility of the iris healing in the wound, and the production of astigmatism due to the position of the corneal cut.

Lebrun's operation much resembles that of Liebreich. The points of puncture and counter-puncture are, however, at the edge of the cornea, one millimetre below its horizontal diameter, while the cut is made upward, its apex reaching a point at the junction of the upper and middle third of the vertical corneal meridian. During the cutting process the edge of the knife is gradually made to change its direction; starting from an angle of thirty degrees with the basis of the cornea it ends at right angles to it. At the middle of the curve, therefore, the cornea is divided vertically (Arlt). The same objection may be made to this operation that was advanced against Liebreich's, though its application here is even more forcible. The danger of anterior synechia is greater, that of astigmatism is imminent, and corneal opacity, from imperfect or delayed healing of the wound, extremely likely to occur. In the opinion of the writer, and in view of the results that a careful collection of statistics has proved to attend the method of peripheric linear extraction, the operation of Lebrun is not to be advised at the present day.

Much more worthy our serious attention is the method proposed by Wecker under the name of "simple extraction," and very recently published. Asserting that the iridectomy itself may prove a source of infection to the wound, from the contact between the cut edges of the iris and the capsular sac, and claiming that the peripheric position of the cut in Graefe's operation, and its consequent vicinity to the ciliary body has given rise to a possibility of sympathetic ophthalmia not previously existing, he boldly proposes a return to the old principle of flap extraction, but in a modified form. And he bases this proposal, in part, on our possession of three agents formerly unknown, cocain, which destroys pain and thus prevents struggling and straining; eserine, which prevents prolapse of the iris and itself gains increased activity from its combination with cocain; and iodoform, which furthers the agglutination of the wound. And yet other advantages are to be gained by the use of the usual antiseptic precautions.

The instruments are placed in a two per cent. bath of carbolic acid, and taken from it as they are needed. The following solution of cocain is used on the eye: cocain hydrochlorat., 0.50 ctgr.; hydrarg. bichlorid., 0.002 milligr.; aq. dest., 10 Gm.; and is applied five minutes and again three minutes before the operation. The eye is cleansed with a pledget of lint dipped in a solution containing four per cent. of boracic and one per cent. of salicylic acid. The dressings to be subsequently used are also soaked in this solution.

The assistant, whose hands have been carefully disinfected, raises the upper lid. The eye is fixed with forceps tipped with rubber, being seized below the horizontal diameter and to the inside of the cornea, thus depressing the lower lid. The upper third of the cornea is then carefully divided with a knife as long as that used in Graefe's operation, but only half as wide; the puncture and counter-puncture being made precisely at the corneal edge. The capsule is then opened with the simple cysti-

tome, after which the crystalline is expelled, pressure being made at the base of the cornea, through the lower lid, while the upper lip of the wound is at the same time slightly depressed by means of pressure made through the upper lid. The lens once removed, a drop of a half of one per cent. solution of eserine is applied, after which efforts are made to press out remaining cortical masses from the pupil, no attention being at first paid to the prolapsed iris. In fact, should the central pupil be spontaneously restored, it may be necessary to again produce a prolapse, for the sake of the wider area thus disclosed, and the increased facility with which cortical remains may be evacuated. Finally, the iris may be replaced, either by simple rubbing practised through the upper lid over the corneal surface, or by the use of the rubber spatula. In the rarer cases, in which replacement cannot be permanently effected, a portion of the iris must be excised.

The wound is now covered with a thin layer of iodoform, by means of a small rubber spatula designed for this purpose. After this the dressings are applied, the pad and tufts of charpie having been soaked in the solution already described. Wecker examines the eye for the first time on the fourth day, removes the dressings finally on the sixth, and then instils atropine if cortical masses are found in the pupillary area.

The true value of this operation cannot as yet be correctly estimated. As has been seen, it offers the advantage of a round, movable, central pupil, and the drawback of an increased difficulty in the removal of cortical masses that may have been left behind after the escape of the nucleus. It would therefore seem especially applicable to cases in which the nucleus is large and hard, with very little adherent corticalis. On one point its author does not dwell, and that is the difficulty of its performance. The carrying the slender knife through the anterior chamber, and the completion of the cut without transfixing or excising part of the iris, requires a keen eye and a steady hand. Peripheric linear extraction is undoubtedly an easier operation. This, however, should not weigh in the balance against a claim of positive advantage, both from non-mutilation of the iris, and escape from a possible danger of sympathetic inflammation. The statistics collected during the next few years will settle the question.

Flap Extraction.—No article on cataract would be complete without a description of this method, which for so many years stood at the head of all operations for senile cataract, and whose complete eclipse by the proceeding of Graefe is due, not to the character of the result furnished, but rather to the increased percentage of success that attends the latter operation. For it must be remembered that flap extraction, resulting in recovery, leaves a better-looking and more useful eye than any proceeding for the removal of cataract that has ever yet been devised, with the single exception of reclination. Instead of a mutilation of the iris there is a fair, round, central pupil. Instead of the disturbing effects of an iridectomy, there exists perfect protection against a sudden excess of light. Instead of a scar across the face of the cornea, there is simply a cicatricial union of half its periphery. But, on the whole, this method loses more eyes in a hundred than the peripheric linear, and has hence yielded to the logic of statistics.

It may still, however, be required in the case of a lens dislocated into the anterior chamber.

It is not advisable to perform the operation without an assistant. Although the spring speculum may be used to separate the lids, the finger is far preferable, both on account of the ready closure which its withdrawal permits, and also owing to the diminished danger of pressure on the eyeball. The patient being in a recumbent position, the operator sits on the edge of the bed in front of him, generally on his right side. The left hand is employed for operating on the right eye, the right on the left. The knife used is shown in Fig. 585. If we assume that the left eye is to be operated on, the assistant takes his stand behind the patient's head. He draws down the lower lid with his right forefinger, being careful not to evert it, and spreads his remaining fingers in such a way that they may interfere with the movements of the operator as little as possible. With the forefinger of the left hand he raises the upper lid, drawing it gently upward, parallel with, but not away from, the eyeball, pressure being made against the edge of the orbit. The operator fixes the eyeball, below the cornea, with the ordinary fixation forceps. Holding the knife with its edge downward, he introduces the point in the horizontal meridian of the cornea, just at its transparent edge, and having penetrated into the anterior chamber, carries the blade rapidly across it, keeping it parallel with the iris, until it emerges on the opposite side at a point corresponding to that at which it entered. The eyeball, being now held on the knife, is thus perfectly controlled, and the fixation forceps may be dispensed with. The handle of the knife is now slightly thrown back toward the temple, and the blade pushed gently but steadily forward, completing the cut, if possible, without withdrawing the blade at all backward; great care being taken to inflict no unnecessary violence on the cornea by pulling or twisting. As the cut is completed the assistant allows the upper lid to escape from his finger and gently descend. The peculiar wedge-shape of the knife used thus gives us a semicircular cut, extending around the entire periphery of the lower half of the cornea, the length of the wound being about nine millimetres, and its capacity of opening in the vicinity of four millimetres; thus affording ample space for the passage of the largest cataracts.

Fig. 585.—Beer's Knife.

Great care must be taken not to draw back the knife before the counter-puncture has been made, and if possible before the completion of the cut; and the hand of the operator must be perfectly steady, in order to keep the blade always in the same plane. A neglect of either of these precautions might result in the premature escape of the aqueous humor, and the folding of the iris over the edge of the knife. Should this latter accident happen, gentle pressure against the cornea with the middle finger will often cause the iris to recede. If it is impossible to effect this, the cut must be completed without regard to the slight deformity to the pupil that would result from the excision of a small piece of the iris substance.

The cut just described can also be made upward, with equally good result. This course offers no special advantages; and the execution in this direction is, in many cases, somewhat more difficult.

The operator now himself assumes the raising of the upper lid; using for that purpose the thumb of the right hand. Directing the patient to look down he lifts up the flap with the back of the cystitome, which is so held that its cutting edge looks downward, and whose shaft now occupies the anterior chamber, while its point remains external to the eyeball, projecting inward from the inner corneal edge. Drawing the instrument, in this position, from left to right, he causes its point to glide into the anterior chamber. Once opposite the face of the lens, he makes a half revolution by slightly twirling the handle between the thumb and fingers, until the cutting edge is in contact with the anterior capsule. The knife being rapidly drawn along its face, a horizontal opening is made. Another opening should be made, at right angles to the first, the point of the cystitome having first been disengaged from the lens substance and passed upward to the spot at which the incision is to commence. The instrument is then laid over on its back and withdrawn from the eye, the process by which it entered being simply reversed.

To effect the delivery of the lens the patient is directed to look up. The surgeon raises the upper lid with the thumb of one hand, while he places the forefinger of the other on the lower lid. Gentle pressure on the eye, made with the thumb through the upper lid, causes the lens to turn on its horizontal axis, and its lower edge to enter the wound. By now making the upper lid descend over the cornea in a succession of sweeping movements, the lens

is, as it were, coaxed out and escapes from the eye. After its greatest diameter has once entered the wound, the rest passes with very little persuasion. If it was already dislocated into the anterior chamber it will escape as soon as the cut is completed. After the removal of the lens the patient is allowed to take a brief rest. The eye must then be carefully inspected to see whether the pupil is free from cortical remains, whether the iris is well in place, and whether the edges of the wound are in proper apposition. Much information as to the state of the pupil may be gained by ascertaining whether fingers can be counted a short distance off. If there is a prolapse of the iris, it may often be made to recede by lightly rubbing the upper lid against the cornea; but if this cannot be effected it must be excised.

The after-treatment of flap extraction is similar to that already described under the head of Peripheric Linear Extraction, the dressings being identical. Less freedom, however, can be allowed the patient immediately after the operation, as sudden movements must be carefully guarded against, and the presence of a cough might be extremely prejudicial. In brief, the proper healing of the wound largely depends on the preservation of perfect quiet, on the part of the patient, during the first twenty-four hours. Occasional change, for a few minutes, from a recumbent to a sitting posture may be allowed. For several days the food should be liquid, or at least quite soft, and all chewing is to be avoided.

Two great causes of failure—namely, corneal suppuration and iritis—are unquestionably more apt to complicate this operation than that of Graefe; and their comparative infrequency after the latter have led to its general adoption at the present day. Some very few cases, however, still remain in which flap extraction might with justice be preferred. Besides being applicable to dislocations of the lens into the anterior chamber, it is especially available where a foreign body is situated in the lens, and requires to be extracted with it; also where a cicatricial condition of the upper part of the cornea prevents peripheric linear extraction in this region.

The description of a single remaining operation, wholly given up to-day in civilized communities, on account of the dangers to which it exposes the eye, but still in general use among the natives of India, will be of interest in an historical point of view.

Reclination.—This is the oldest method known, and is referred to by both Galen and Celsus. It consists, in brief, in the removal of the opaque lens from the axis of vision by pressing it downward, or downward and backward, with a suitably shaped needle, introduced for this purpose sometimes through the cornea, but more generally through the sclerotic.

Fig. 586.—Reclination Needle.

According to Arlt, the operation would be performed in the following manner: The pupil is artificially dilated. The lids being separated by a spring speculum, and the eyeball seized with the fixation forceps, the needle (Fig. 586), with its convexity directed upward, is made to penetrate the sclerotic somewhat below the horizontal meridian, and about four millimetres from the corneal edge. One cutting edge of the needle is directed toward the anterior, the other toward the posterior pole, and the point toward the middle of the vitreous humor. "After it has passed in up to its neck, the handle is turned on its axis (toward the thumb), so that the convexity, formerly upward, is now directed forward. The handle is now lowered toward the lobe of the ear, in order that the point may be pushed forward toward the edge of the lens, and farther, until it enters the posterior chamber. Steadily pushed forward, the needle now enters the pupil, where its metallic sheen is recognized, provided it emerges external to the capsule. When the point has once reached the opposite pupillary edge and passed behind it, the instrument is to be regarded as a lever, the fulcrum being situated in the sclerotic. The handle is now raised toward the nasal eminence, and the lens depressed downward and outward. The handle is to be raised no higher than is sufficient to form an angle of about one hundred and twenty degrees with the corneal basis. A brief pause with the needle in this position is necessary, in order that the vitreous may settle down properly around the lens. The instrument, held thus, is withdrawn up to its neck, and then returned to the position which it occupied before its advance toward the edge of the lens. If a single performance of the manœuvre results in the lens remaining fixed, a thing usual when the consistency of the vitreous humor is normal (always provided the lens has been attacked at its centre of gravity), the handle is to be twirled round in the opposite direction, away from the thumb, and withdrawn from the eye in the line of the original puncture. Should the lens rise before the withdrawal of the needle, a second and third effort at replacement may be made. Further attempts would hardly accomplish the object, and might easily do harm by breaking up the structure of the vitreous." [15]

At the present day this operation for cataract is probably more largely performed in India than in any other part of the world. The armamentarium of the native travelling oculist consists of a sharp knife, the blade of which is wound around with some material, so as to leave only the point free, and a copper probe or spatula. With the former an incision is made through the sclerotic, while the latter is introduced through this opening, and the lens depressed. The inability of these self-educated practitioners to do extraction is, of course, one reason why this method is so generally used. But, in addition to this, we are told that suppurative keratitis is exceedingly frequent among the poor, rice-fed Hindoos after flap extraction. Thirty per cent. of the operations formerly performed in Calcutta are said to have failed in this way.[16] The writer here quoted also states that hardly a week passes that he does not see, in the hospitals of Calcutta, patients, on whom reclination has been done, suffering from either inflammation of the choroid, or from retino-choroiditis.

When reclination is followed by success, the lens, probably becomes encapsuled in its new position. If, on the other hand, inflammation follows, it ordinarily involves the iris, choroid, or ciliary body, or may attack all three. The outcome is, of course, most serious. Secondary glaucoma may follow. But the lens, even when encapsuled, may subsequently act as a foreign body. For it is to be remembered that the complete absorption of a hard cataract in this position is not to be reckoned on. Destructive inflammation may come on years later, and all vision be destroyed. Sympathetic inflammation of the other eye may even ensue. It is, therefore, hardly possible to conceive of circumstances in which the operation of reclination may, at the present day, be regarded as justifiable.

Antiseptic Measures.—The subject of antiseptic precautions to be taken in connection with cataract operations claims our attention, now that the operations themselves have been detailed and described. And it must be premised that, on the subject of the necessity of these precautions, and in the estimate of their value, there is a radical difference of opinion. While admitting the great value of strict cleanliness, both of the patient, the instruments, and the operator, men of the utmost eminence and of the largest experience have denied the necessity of special antisepsis. Knapp has publicly stated that he regards antiseptic treatment as a superfluous complication, as lost time, and denies that its introduction into ophthalmological practice is to be regarded as a step in advance. Gradenigo prefers cleanliness and plenty of pure water. Hirschberg considers antisepsis unnecessary in institutions enjoying a good situation. In the same sense speak Brailey and others.

On the other hand, men of equal eminence take a directly opposite view of the subject. Horner has thrown all the weight of his ripened judgment and large experience into this scale; and he is corroborated by Sattler, Jakobson, and many more. Such being the case, it is at least proper to give a list of the various substances used in this connection, and to state the precautions ordinarily recommended to be taken.

Corrosive sublimate is highly praised as an antiseptic agent, is readily obtained, and costs but little. Used in the strength of 0.25 to 1,000, it may be employed for bathing the hands of the operator and assistants, as well as of the attendants in the wards. But it injures surgical instruments. For these a three to four per cent. solution of carbolic acid is better, and the sponges may also be treated with the same liquid. Boracic acid in the strength of three to four per cent., salicylic acid one-third of one per cent., thymol, and iodoform have all been used.

The experience of Jakobson in this connection forms the subject of a recent article [17] in "Graefe's Archives," and may well be detailed. Previous to his use of antisepsis his percentage of loss in peripheric linear extraction varied between three and five. Within the last two years, out of one hundred and thirty-seven extractions of all kinds, complicated and uncomplicated, he has not had a single instance of suppuration; and his percentage of good results has appreciably increased. He is in the habit of placing all his instruments in a two per cent. solution of carbolic acid one hour before he operates. Those that are to be introduced into the interior of the eye are taken from the bath five minutes before the operation, washed in absolute alcohol, and then replaced. When required they are used on the eye without being dried or wiped. Shortly before the operation the freshly prepared bed and its surroundings are thoroughly sprayed with a carbolized solution. Two days before, the patient has had a bath, and his eyes have been bandaged for twenty-four hours, in order to see whether there is any disposition to the formation of secretion. One day before, the conjunctival sac, lids, and neighboring parts are carefully washed with a four per cent. solution of boracic acid. This is repeated on the morning of the operation. An hour beforehand borated cotton is applied to the eye, and kept on up to the last minute. The operator and the rest carefully wash their hands. Instead of sponges or cloths only borated cotton is used for cleansing purposes. Iodoform is applied the whole length of the wound before closing the eye. Spray is not used, either during the operation or when the dressings are changed. As regards the dressings themselves, the linen pads that come next the eye may have been soaked in the boracic acid or sublimate solution, and borated or sublimated cotton may be used, instead of charpie, to pack over the eye.

History of Extraction.—It is uncertain whether the ancients were acquainted with this method; it is probable, however, that they were, as passages in Galen and Pliny have been thought to refer to the removal of the cataract from the eye. At all events, if known, it fell into nearly complete disuse and oblivion; and not until the time of Daviel, in 1750, did it begin to be cultivated as a recognized procedure. This surgeon used numerous instruments, consisting of narrow sharp and blunt knives, and scissors; he made at first a small opening in the cornea, enlarged it afterward, and then removed the lens. His followers sought to improve his method by simplifying its application; and soon superseded the various instruments he had used by a single knife. This was subsequently modified, especially by Beer, to whom we owe the form of knife used in flap extraction at the present day. Gradually more exact rules were laid down for the performance of this operation; the situation and size of the cut, the best method of opening the capsule and pressing out the lens were all perfected. Despite the utmost care, however, used in carrying out the various steps of the operation and in the after-treatment of the patient, there was an appreciable percentage of loss; owing largely to one of three causes—diffuse suppuration of the corneal flap, defined suppuration of the same, and iritis. To diminish the danger of the second of these, but more particularly to guard against the last, Mooren proposed, in 1862, that a preliminary iridectomy be performed some two weeks before the extraction. The results which he obtained by pursuing this method were proved to be incontestably superior to those that had followed the simple operation. This was the first great step forward in the path now pursued. It allowed the lens to emerge more readily, and subjected the iris to less danger from pressure and bruising in the process. In 1863 Jakobson proposed the following operation: He narcotized his patient, and made a lower section in the sclero-corneal junction, practising a broad iridectomy downward after the removal of the lens. He thus gained the advantage of doing the whole operation at one time, but incurred the disturbing effect of an iridectomy downward. Previous to the bringing forward of either of these methods, Schuft (now Waldau) had invented, and in 1860 published, a series of spoons intended to remove the lens through a small wound at the edge of the cornea. These were, however, large and clumsy, did great violence to the eye, and were, in 1865, superseded by others much more delicate, invented by Bowman and Critchett. Outspooning remained for a time a favorite method in England, but was afterward given up on account of the dangers which it involved. In 1865 Graefe brought out the method that bears his name, and gave an account of it to the Heidelberg Society at its annual meeting. It quickly found its way into general favor, and, with the modification in the cut described in the course of this article, has remained the popular method up to the present day.

Other modern procedures demand a brief notice. In 1866 Alexander Pagenstecher described an operation for removing the lens in its capsule through a broad incision made with a lance-knife, and by means of an iridectomy downward and outward. A specially constructed scoop was employed. In 1867 Weber devised a lance-knife, twelve millimetres broad and somewhat concave on its back. With this he entered the anterior chamber at the lower or lower-inner edge of the cornea, in the plane of its basis, and made a wound ten milimetres in length. If he thought it best to remove any iris, he excised but a small piece, and that from the pupillary edge. The opening of the capsule and removal of the lens, which latter was effected by pressure, completed the operation. Kuechler, in 1868, proposed to remove the lens through the natural pupil, making an incision straight across the cornea in its horizontal meridian. Analogous to this are the operations of Liebreich and Lebrun, already described.

A consideration of the following figures will show why flap extraction has fallen into disuse, and why the peripheric linear method has taken its place.

Graefe's own statistics were as follows: Simple flap extractions, 600—loss, 7 per cent.; flap extractions with iridectomy, 900—loss, 5 per cent.; linear extractions, 600—loss, 2.8 per cent. Horner gives: Linear extractions, 1,088—loss, 2.67 per cent. Noyes has collected, from various sources: Flap extractions, 10,094—loss, 10.4 per cent.; linear extractions, 10,661—loss, 5.8 per cent.

The larger proportion of loss given, according to the figures of Dr. Noyes, would naturally be connected with the large number and varying skill of the surgeons whose results are thus grouped. *Hasket Derby.*

[1] Otto Becker: Zur Anatomie der gesunden und kranken Linse. Wiesbaden, 1883.
[2] Klinische Monatsblätter für Augenheilkunde, June, 1884, pp. 199, 200.
[3] Nouveau Dictionnaire de Médicine et de Chirurgie Pratiques, vol. vi., p. 481. [4] Hufeland's Journal, March, 1844.
[5] O. Becker: Graefe-Saemisch, vol. v., p. 256. [6] Loc. cit., p. 259.
[7] Becker: Graefe-Saemisch, vol. v., pp. 178, 179.
[8] Traité théorique et pratique des Maladies des Yeux, t. ii., p. 171.
[9] Graefe-Saemisch, vol. iii., p. 263. [10] A. f. Oph., 30, ii., S. 266.
[11] Wecker: Thérapeutique Oculaire, p. 466.
[12] Graefe-Saemisch, vol. iii., p. 295.
[13] Graefe-Saemisch, vol. v., pp. 341, 342.
[14] Eine neue Methode der Cataract-Extraction, pp. 12, 13, 14. Berlin, 1872.
[15] Graefe-Saemisch, vol. iii., p. 254.
[16] Macnamara: Diseases of the Eye, p. 525.
[17] Archiv für Ophthalmologie, Jahrg. 30, Abth. 2.

END OF VOLUME I.